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ELECTRONICS

SCIENCE & TECHNOLOGY

TEACHER
TIMER

SPEECH
PROCESSOR

FUNGEN
SIG-GEN

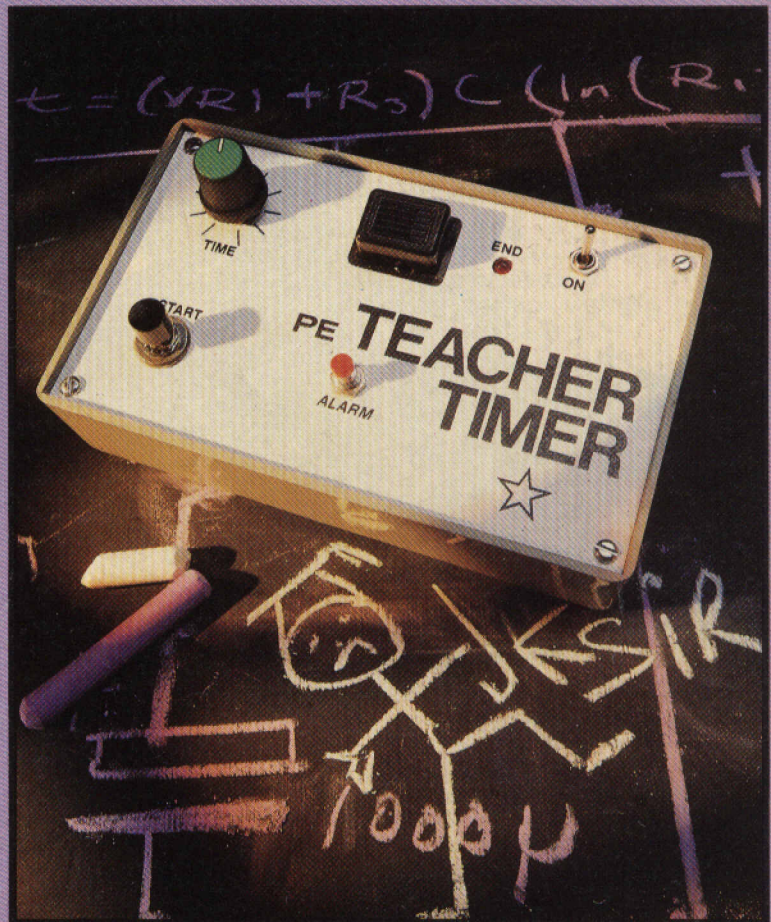
AUTO LIGHT
CONTROLLER

DESIGN — MIDI
INTERFACE FACTS AND FUNCTIONS

COMPUTING —
SPEECH SYNTHESING PHONEMES

TECHNOLOGY —
CAPACITORS AND HI-FI QUALITIES

EXPERIMENTAL ELECTRONICS
EXCITING DESIGN IDEAS AND PRACTICAL APPLICATIONS

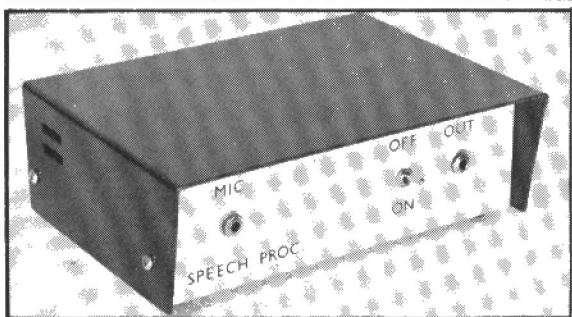


PLUS:

- ★ SPACEWATCH
- ★ LEADING EDGE
- ★ INDUSTRY NEWS
- ★ LOGIC PUZZLE
- ★ MARKET PLACE
- ★ PROJECTS GUIDE

NEW SERIES
G.C.S.E.
PROJECT IDEAS

THE SCIENCE MAGAZINE
FOR SERIOUS ELECTRONICS AND COMPUTER ENTHUSIASTS

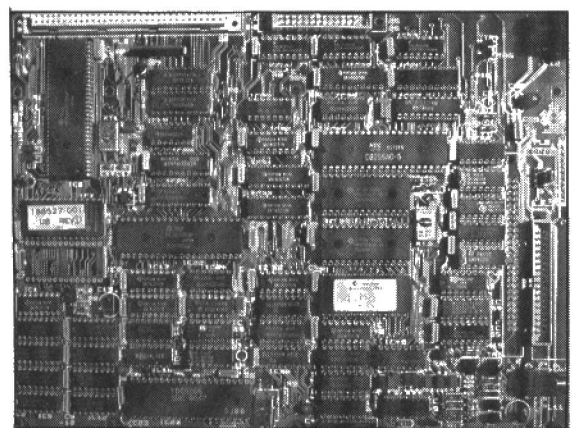
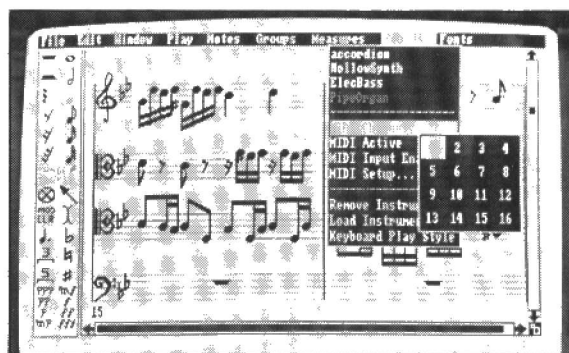


CONSTRUCTIONAL PROJECTS

- TEACHER TIMER** by Tim Pike 12
The first project of an important new series of constructional articles aimed at students taking G.C.S.E. electronics courses.
- SPEECH PROCESSOR** by the Prof 26
Clearly outspoken as ever, the Prof demonstrates how the clarity of transmitted speech signals can be considerably enhanced.
- FUNGEN** by Andrew Armstrong and Ron Keeley 35
A fundamental three-waveform signal generator that can be fun to build and functional in purpose for both amateur and professional roles.
- CORRIDOR LIGHT CONTROL** by Giles Read 40
Lighten your darkness economically with a preset lamp cut off controller.
- MICRO-CHAT PART TWO** by Malcolm Harvey 49
Concluding this highly versatile computer controlled text to speech synthesiser by detailing the construction and programming considerations.

SPECIAL FEATURES

- MIDI INTERFACING** by the Prof 19
Modern hi-tech music relies heavily on the ability of instruments to talk to each other via dedicated data links, and it's simpler than you might think.
- COMPONENT TECHNOLOGY PART TWO** by Graham Nalty 42
Capacitor type and quality actively affects the achievement, or otherwise, of hi-fi audio, but even average performance can be improved by strategic substitution.



REGULAR FEATURES

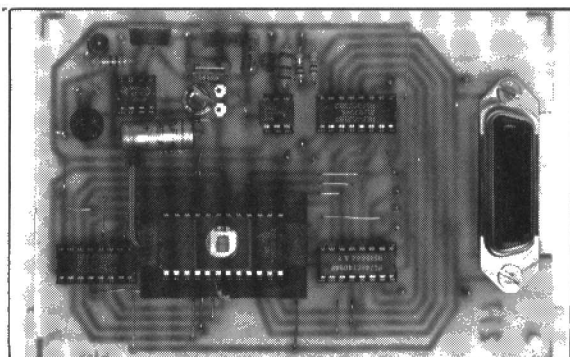
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NEXT MONTH . . .

DIGITAL LOCKS – A G.C.S.E. PROJECT IDEA • 4K EPROM PROGRAMMER • CLICK ELIMINATOR • PROGRAMMABLE LOGIC DEVICES • GUITAR TO SYNTHESIZER INTERFACE • STABLE POWER SUPPLY

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THE SCIENCE MAGAZINE FOR SERIOUS ELECTRONICS ENTHUSIASTS

CATALOGUE CASEBOOK



Last month we received details of the following catalogues and literature:

Cirkit Summer 1987 Catalogue. Its 170 pages contains many more new items especially in test gear. Larger stocks and a better service for electronics constructors are offered, and there is also another competition. **Cirkit**, Park Lane, Broxbourne, Herts, EN10 7NQ.

Electronics Brokers. From a leading UK distributor of electronic test and measurement equipment, a new 16-page 1987 products guide, clearly illustrated with prices. **Electronic Brokers Ltd**, 140-146 Camden Street, London NW1 9BP.

Hitachi. Nearly 150 pages of data relating to liquid crystal modules, some of them measuring nearly 300 x 200 mm. Hitachi have several distributors in the UK, but their main office is at 21 Upton Road, Watford, Herts, WD1 7TB.

Phonosonics. New fully reset catalogue of geiger counters and musical effects kits, most of them previously published in PE and other periodicals. **Phonosonics**, 8 Finucane Drive, Orpington, Kent, BR5 4CC.

Power Selector Guide. Babani BP235. £4.95 from usual stockists.

Transistor Selection Guide. Babani BP234. £4.95 from usual stockists.

TRW Electronic Components. The TRW catalogue of AC & DC Cooling Fans claims over 300 component product lines, and that quality and reliability backed by more than 40 years experience are the key considerations. Available through **MCP Electronics Ltd**, 26-32 Rosemont Road, Alperton, Middx, HA0 4QY.

Hi-rise blocks

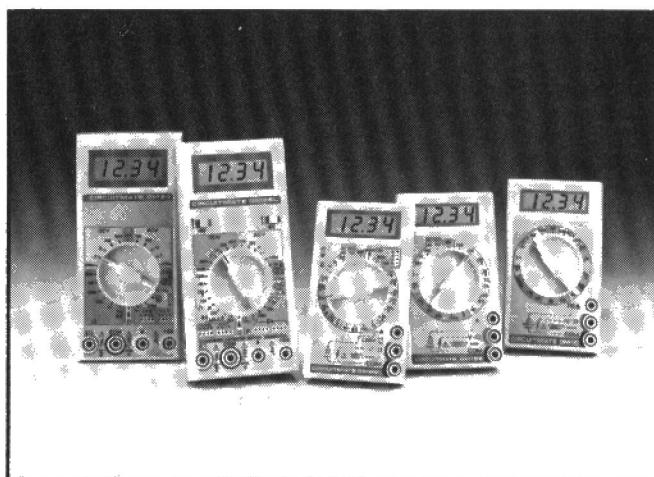
Components and Electronics Ltd, a new Surrey based connector supplier, have introduced a new range of low cost 2, 3 and 4-way modular terminal block connectors, designed for use with PCBs.

Board mounting receptacles can be supplied with either straight or right-angled

terminations. Positive latching of plug to receptacle and polarisation is incorporated. The modules can be stacked to give the required connector size and are available in red or green to enable colour coding.

For further information contact **C&E Ltd**, PO Box 88, Haslemere, Surrey GU27 2RF. Tel: (0428) 54141.

WHAT'S NEW



Many meters

Five new low-cost handheld digital multimeters have been added to the Circuitmate range of instruments by Beckman Industrial. These are the pocket-size DM10, DM15B and DM20L, for applications including computer and electronic equipment servicing, education and domestic use, and the full size, feature-packed DM23 and DM25L which can double as bench instruments. The prices of the instruments are from £32.50 (plus VAT).

The DM10 has d.c. voltage ranges of 200mV to 1000V, a.c. voltage ranges of 200 and 500V, d.c. current ranges of 200µA to 200mA and resistance ranges of 200Ω to 2MegΩ. It also incorporates a diode test function. The DM15B and 20L have, in addition, a.c. voltage ranges of 200mV to 750V, 200µA to 2A a.c. and d.c. current ranges and 200Ω to 2000MΩ resistance ranges. They also have a diode test function and a continuity test function with beeper. Model DM20L includes a built-in 20MHz logic probe that detects 25ns pulses and measures transistor hFE d.c. current gain.

Equipped with a large switch for simple function and range selection, the three instruments are equally useful on the bench or in the field. Basic accuracy on d.c. voltage is 0.8%. They each measure 121x70x24mm and weigh approximately 200 grams.

Users who prefer a traditional, full-size meter that doubles as a bench instrument can choose between the DM23 and DM25L. The basic functions are the same, with d.c. voltage ranges of 200mV to 1000V (basic accuracy 0.8%), a.c. voltage ranges of 200mV to 750V, d.c. and a.c. current ranges of 200µA to 10A and resistance ranges of 200Ω to 2000MegΩ. A diode test function and a continuity test function

with beeper is also included.

Model DM25L measures transistor hFE and includes a built-in 20MHz logic probe that detects 25ns pulses, as well as five capacitance ranges for measurement of capacitors as large as 20µF.

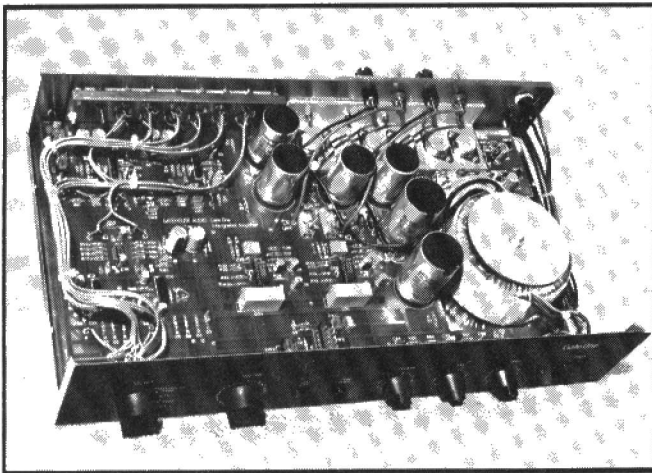
Accessories available for all the instruments include carrying cases, high-current clamps and high-voltage probes and an r.f. probe.

For further details contact **Beckman Industrial Ltd.**, Temple House, 43-48 New Street, Birmingham B2 4LJ. Tel: 021-643 8899.

I scream cones

The sound of the legendary sixties rock guitarists stemmed from long extinct cobalt magnet speakers with fragile paper voice-coils, which gave the ideal mix of tonal nuance and overdrive harmonics (otherwise known as distortion). Increasing costs and higher power demand saw the demise of these revered relics of a fabulous decade. Speaker manufacturers worldwide have striven for years to re-create, using modern and cost-effective materials, the subtle tonal colours and overdrive characteristics of the most sought after rock sound of all time. This has finally been achieved, say Fane Acoustics, with the Fane Medusa, a breakthrough in guitar speaker design which combines the best of modern design technology and materials re-creating the rock guitar sound of 25 years ago. Two models are available, the Medusa 30 for 4 by 12 in stacks, and the Medusa 150 for single or twin combos.

Full information from **Audio Factors**, Audio House, Robin Lane, Pudsey, Leeds. Tel: (0532) 561949.



Audiophile Amplifier Kit

The Gate One amplifier kit is a top quality professional engineered amplifier that has the sonic performance, build, quality and finish of amplifiers in the £300-£400 price range, yet costs only £161 inclusive.

Available from Gatehouse Audio, the amplifier specification includes a host of features common to most mid-range ready built amplifiers combined with various aspects of design and performance normally associated with more esoteric products. A ready built version is available for £201.25.

Features include a 40 + 40 watt output, a fully stabilised high current power supply, high current TO3 power supply and output transistors, 225VA

transformer with 5 reservoir capacitors, double sided earth plane pcb, minimum capacitor passive RIAA and tone control equalisation, sub-sonic filter, low end bass boost switch and MM/MC, CD, Radio, Tape 1, Tape 2 inputs and tape output phono sockets mounted on an isolated input panel to eliminate eddy current effects in the amplifier chassis.

A solder resist and a component legend on the pcb simplify assembly. Inputs are connected directly to the selector switch and not routed across an unscreened pcb or subject to multiple stages of potentially unreliable switch contacts (as is common with some designs). All resistors are 1% metal film and film capacitors are used wherever

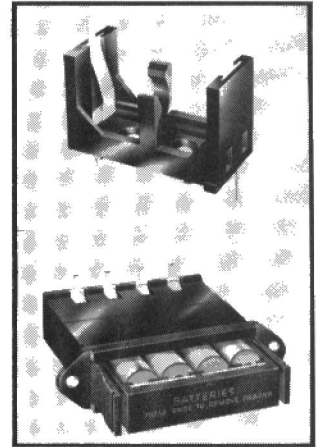
possible. An earth plane on the pcb aids sonic performance by screening sensitive components and signal tracks, and also allows an ideal power supply star feed and earth return network. The fully stabilised supply has no ripple.

The outer case has a high quality black gloss finish and the separate front panel is printed in gloss white. All metalwork is ready drilled and the appearance and performance of the fully built amplifier will make all constructors proud of their work.

The sonic ability of the amplifier is quite superb, the sound is detailed, articulate yet not over clinical. Dynamics are produced with a bite that brings good recordings alive.

Jeremy Lord, designer of Gate One and proprietor of Gatehouse Audio, comes from a musical family as both his parents were professional musicians.

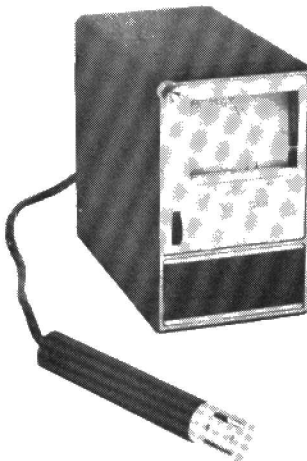
Contact: Jeremy Lord, Gatehouse Audio, 105 High Street, Evesham, Worcestershire, WR11 4EB. Tel: 0386 48875.



AA Snugly OK

BULGIN announce a new 1/2AA size battery holder (top) for PCB or base mounting and a 4xAA (R6) size drawer type battery holder (bottom) for panel mounting, as shown in the photographs.

Contact: A.F. Bulgin & Co. PLC, Bypass Road, Barking, Essex, IG11 0AZ. Telephone: 01-594 5588



Channel Record

THE MODEL M2124 chart recorder from Channel Electronics provides an accurate readout of temperature and relative humidity over the range of 0 to 50°C or -10 to 40°C plus 10 to 90% RH. Temperature is measured by a PT100 probe and humidity by a metalised film capacitance sensor.

Each eight seconds the recorder prints a dot for temperature and four seconds later prints one for humidity. The dots appear as a continuous line and the instrument thus provides two separate traces on pressure sensitive chart paper without the use of ink or cartridges.

At a standard chart speed of 1" per hour, the recorder can be left unattended for one month. Subsequent attention is limited to periodically changing the chart roll; no further servicing is required. If necessary, the chart

speed can easily be changed by means of clip-in interchangeable gear boxes. With an accuracy of $\pm 1^\circ\text{C}$ and $\pm 3\%$ RH, the instrument is ideal for applications as diverse as computer rooms; libraries; museums and art galleries; hospitals; clinics; laboratories; clean rooms; greenhouses; photographic and paper storage; food processing units and so on.

The MODEL M2124 is available in either re-roll or tear-off mode. In the re-roll mode the chart is wound on to a spool for review at a later date.

Contact: Channel Electronics (Sussex) Ltd, P.O. Box 58, Seaford BN25 3JB Sussex, Tel: 0323 894961

Longer braid

Cobonic Ltd are producing their popular 3S-Wick desolder braid in 15m and 25m lengths. The cost per length on this new package has been reduced compared to the standard 1.5m dispenser reel which is still available. 3S-Wick is characterised by a highly heat conductive woven pattern of pure copper fibres and its patented coating (British patent 1,546,602). The high heat-conductivity of the weaving is necessary to draw off quickly any excess heat from soldering tips to limit rate of temperature increase and peak temperature level.

For further information contact Cobonic Ltd., 32 Ludlow Road, Guildford, Surrey GU2 5NW. Tel: (0483) 505260.

COUNTDOWN

If you are organising any electronic, computing, electrical, scientific or radio event, big or small, drop us a line. We shall be glad to include it here. Send details to **COUNTDOWN**, Practical Electronics, Intra House, 193 Uxbridge Road, London W12 9RA.

PLEASE NOTE: Some events listed here may be trade only, or restricted to certain categories of visitor. Also, please check dates, times and other relevant details with the organisers before setting out as we cannot guarantee information accuracy.

Periodic Hitachi Graphics User Group. 0923-46488.

Periodic The 405 Line Society - historical TV preservation. Parkstone (Dorset) 748072.

Aug 28-Sep 6. International Audio & Video Fair Berlin. 0511 529999.

Sep 1-4. International Conference on Japanese Information in Science Technology and Commerce. University of Warwick. 01-323-7924.

Sep 3-7. SIM-HI-FI-IVES European showcase of music and consumer electronics. Milan 01-4815541.

Sep 15-18. International Conference on Japanese Information in Science Technology and Commerce. University of Warwick. 01-323-7924.

Sep 15. Outdoor Sound propagation (IOA). Open University, Milton Keynes. 031-225-2143.

Sep 15-18. Design Engineering Show. National Exhibition Centre, Birmingham. 01-891 5051.

Oct 6-8. Internecon Packaging Show. Metropole Convention Centre, Brighton. 01-891-5051.

Oct 13-15. British Laboratory Week '87. Grand Hall, Olympia, London. 0799-26699.

CHIP COUNT!

This month's list of new component details received — mainly chips, but other items may be included.

HG62E series. Very high speed CMOS gate arrays, 0.7ns, upto 24k gate capacity, built in autodiagnostic functions. (HT).

OTV 101. New optically isolating amplifier for bidirectional video transmission. (EL).

PLHS18P8A. Low cost 20ns programmable AND-array logic device. (ML).

TP 1467. Ultra low offset, very high speed 1435 dynamic equivalent. (MC).

TP 1468. Very high power op amp, 10 amp output for supplies to $\pm 50V$ max. (MC).

TP 1481. $\pm 70V80mA$ output high voltage op amp. (MC).

TP 1493. Fast settling 350MHz dual 1437. (MC).

TP 1900. 175MHz video display driver for high resolution. (MC).

TP 4192 and 4193-01. 12-bit resolution A-D converters, 500ns conversion speed. (MC).

TP 4950. Single mode laser diode module, 750 MBit-sec modulation, low threshold current. (MC).

Ultra high speed delay lines — 10 new ranges for delays between 100 and 1000 picoseconds. (BA).

Manufacturers, and contact telephone numbers for further details. (BA) BAL Components 01-836 2205. (EL) Electroustic Ltd, 042 878 611. (HT) Hitachi, 0923 46488. (MC) M.C.P. Electronics Ltd, 01-902-1191 (agents for Teledyne Philbrick). (ML) Mullard, 01-580 6633.

Youthful Engineering

THIS country needs engineers and the Government is encouraging schools to give more time to technical studies. Also to meet the need, Able Publications is producing school learning materials for "young engineers". Engineering workpacks have been designed so that they can be used by non-specialist teachers, training-officers and youth club leaders.

The workpacks involve youngsters in craft and electrical work, working with engineering drawing, construction and operating the machine they have built.

Each pack is centred on a model which demonstrates mechanical movement. These packs provide easily used resource materials for teachers who want to use the concept of pupil-centred discovery learning.

Alternatively, the packs can be used in a more traditional way in which the pupils learn in the course of building a model which has been designed for them. Another approach is to use a mix of both the above methods presenting various projects to pupils each of which when completed could form part of a completed machine.

The objective of these packs is to provide an introduction to the following: Problem-solving and the creative design of structures and movements as an adventure. A range of mechanical movements and structures used in manufacturing industry. Reading engineering drawings and the use of simple sketches suitable for use as 'start-up' projects. Basic maths as required at workshop level, measurement, marking out on various materials, and the significance of tolerances. The importance of care of equipment and tools, fault finding and simple problem solving.

Teachers' notes include an outline of a plan for the use of the package, including a practical sequence showing how the parts of the machine can be made and the model completed and answers to problems and questions set. Subjects covered relate to craft skills, properties of various materials, various fixing methods, the use of engineering drawing and sketching, the use of pulleys, gears and levers, simple electrical wiring.

Contact: Able Publications, 121 London Road, Knebworth, Herts, SG3 6EX. Tel: 0438 812320

Low Distortion Oscillator

THE SA1 audio oscillator from SAGEAUDIO is claimed to represent just about the ultimate in low harmonic distortion sinewave generation.

Several new and unique design techniques have been used together to achieve a level of harmonic distortion typically 30 times lower than virtually all of their competitors, regardless of cost.

The generator produces four different audio spot frequencies of 100Hz, 400Hz, 1kHz, 10kHz accurate to 1% and with an output level up to 1VRMS. This level of frequency accuracy simplifies the distortion measurements using standard distortion analysers and/or fixed filters. Other frequencies are available to order.

The SA1 incorporates a unique noise reference button to allow accurate measurement of harmonics buried below the

noise level. This button when pressed removes the sinewave output without significantly altering the generator's gain, source impedance or residual white noise level. An accurate noise reference can then be measured and subtracted from the THD + noise reading. This reference represents the oscillator noise, the amplifier under test noise and the analyser noise floor.

The SA1 is mains powered, built in a strong durable case with carrying handle/tilt foot and comes complete with a 16 page designers guide to modern low distortion circuit design. There is a full one year guarantee including maintenance and calibration facilities.

Contact: Sage Audio, Construction House, Whitley Street, Bingley, West Yorkshire. BD16 4JH. Tel: 0274 568647.



the 'Photonic Wand' — a long distance light pen attached to a 'helmet' or spectacles which interacts with the computer screen, replacing the need for a keyboard — are typical of the kind of innovative designs the Award Scheme Judges looked for.

Datasolve Award

A 'GAMES Joystick' and a 'Photonic Wand' are just two of some 20 devices entered for the Datasolve Award for 'Technological Innovation to Aid Cerebral Palsy Children'.

Launched on 9th February 1987, the Award Scheme was designed to promote the work carried out by amateurs and small companies to help cerebral palsy children use microcomputers.

To attract funds and stimulate further development in this area, a selection of the most innovative devices entered were presented by Datasolve to representatives of over 100 UK computer companies at this year's Computer Industry Charity Ball.

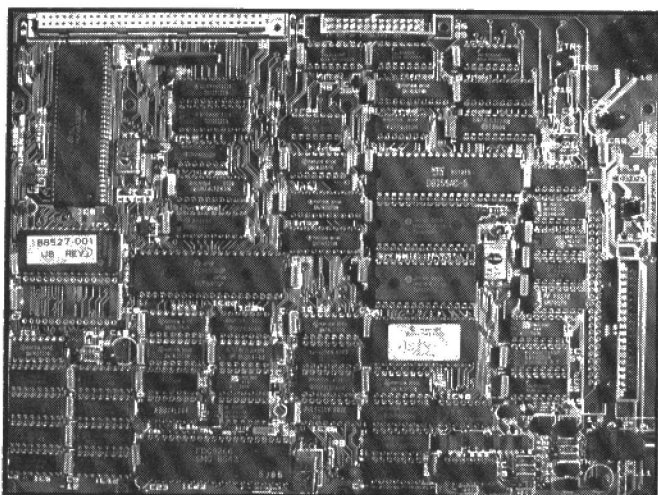
Devices such as the 'Games Joystick' — which helps children with limited control over limb movement to play the same computer games as their able-bodied contemporaries — and

Adam's Appellation

ADAM Hall Supplies, who are specialised hardware and electrical suppliers for sound equipment and allied cabinets, have set up sole distributors for their hardware and fittings in the following countries: CP France, Paris, France; R&R Musical Supplies, Rome, Italy; EXEL, Madrid, Spain.

John Allondale, Sales Director of Adam Hall Supplies said that they were making every effort to improve the service they are giving to Europe, and that they are now looking forward to set up strong distributors in most countries.

Contact: Adam Hall Supplies Ltd, Unit 3, The Cordwainers Temple Farm Industrial Estate Sutton Road, Southend-on-Sea Essex SS2 5RU. Tel: 0702 613922



SNIPER BOARD

Rocketfield Computer Systems announced the Sniper 180 high performance single board computer. Using the most advanced components available, it was designed for OEM, Educational and Industrial applications, to meet the needs of a complete, powerful and compact machine, requiring a power supply, disk drive, keyboard (IBM PC/type) and a monitor.

The Sniper 180 may be used as a development or general purpose system, industrial controller or as an intelligent

terminal in a network or multi-user environment.

It incorporates a CMOS CPU, RS232 serial ports, parallel printer port, floppy disc support, 256k bytes RAM and up to 64K bytes EPROM, optional 32K bytes static RAM, keyboard interface (IBM PC compatible), video system with 24 x 80 display and five attributes all on a double sided 7 x 9.45 inch board. The system is fully expandable via a 64 way Euro Connector.

Using the Hitachi HD64 180 CPU running at 6MHz or 8MHz, this CPU is fully software compatible with the Z80

processor and it incorporates on chip serial channels, DMA controllers, interrupt controller and timer counters. The system uses 256K bytes of dynamic memory.

The on-board EPROM socket may use 2764, 27128, 27256 or 27512 EPROM. There is another 28 pin socket, which may use 8K bytes or 32K bytes static RAM or up to 32K bytes EPROM. The two RS232 serial ports have baud rate between 150 baud and 38.4K baud. Channel A is fully hand shaken.

The printer port is Centronics compatible, and the keyboard is serial IBM PC Compatible. The floppy disk controller can simultaneously control any combination of up to four 3.5", 5.25" or 8" disk drives. The video circuit is based on the 6845 type CRT. Two 8K by 8 static memories are used which allows up to four pages of text. The character generator has up to 1024 characters in a 2764/128 EPROM. Character cell is 8 x 12. Video output is composite and has five attributes blinking inverse, high intensity, underline and blanking. The board can be mounted on 5.25" disk drive.

Contact: Rocketfield Computer Systems, 86 Birch Hall Lane, Manchester M13 0XZ. Tel: 061-224 4032.

Find that pipe

Metal objects, such as pipes, cables and junction boxes, up to 20 or 25cm below floors, walls and ceilings can be detected with a hand-held multi-meter, called the Explorer, from Electronic and Computer Workshop Ltd. The maximum deflection of the high accuracy analogue meter movement reveals the position of the hidden object.

The Explorer also provides all of the normal multi-meter functions, including d.c. voltages of up to 1000V and a.c. of up to 1500V. Currents of up to 30A (a.c. or d.c.) can be measured with two resistance scales and an audio continuity test function. Also provided is a neon lamp phase sequence indicator. Full protection is provided against wrong connection and overload.

Measuring 160x105x40mm, the meter is provided with a shock-proof case, shoulder strap, instruction manual, three test leads and spare fuse. ECW offers the Explorer at an all-in price of £71.53 including VAT and post/packaging.

For further information please contact: **Electronic and Computer Workshops Ltd, 171 Broomfield Road, Chelmsford, Essex CM1 1RY. Tel: (0245) 262149.**

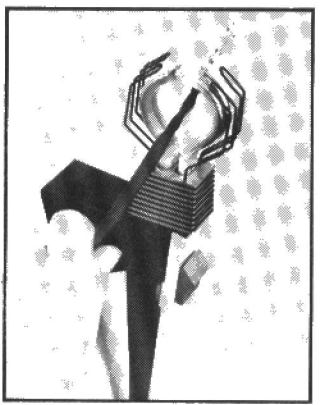
Infrared Glo-Ring

Continuous duty elements in 4 sizes for use with the Glo-Ring Infrared HeatTool are now available from Eraser International Limited. The Glo-Ring is used in the electrical and electronic industries for applications requiring flameless heat, such as heat shrinking, plastic tube bending, soldering, adhesive curing, solder preforms, etc.

The Glo-Ring incorporates quartz encapsulated heating elements which open and close like a thumb and forefinger, encircling the workpiece with infrared heat, at temperatures up to 815°C. the tool is lightweight and can be used in clean rooms as there is no blowing hot air. The new elements allow the unit to be used in a continuous fashion by utilizing the lock-on button of the tool. By using the unit in this fashion, it is not necessary to let the elements cool down or turn the unit off in between operations.

The new continuous elements are available in 4 sizes: 12.7mm, 25.4mm, 50.8mm and 76.2mm. All are plug-in type elements and are interchangeable with the standard intermittent types supplied with the Glo-Ring.

Eraser International Ltd., Unit M, Portway Industrial Estate, Andover, SP10 3LU. 0264 51347



New Multimeter Value

Two new Hung-Chang multimeters, model numbers HC5010 EC (£52.50 exc. VAT) and HC 775 (£33.50), represent "the best value for money on the market" said a spokesman for Cirkit Distribution, who have just introduced the products into the United Kingdom.

The model HC5010 EC, claims the company, offers a range of facilities matching those of much more expensive digital multimeters. It is equipped with a continuity tester giving both audible and visual indications as well as diode and transistor testers, which enable accurate capacitance, conductance and temperature measurements to be taken.

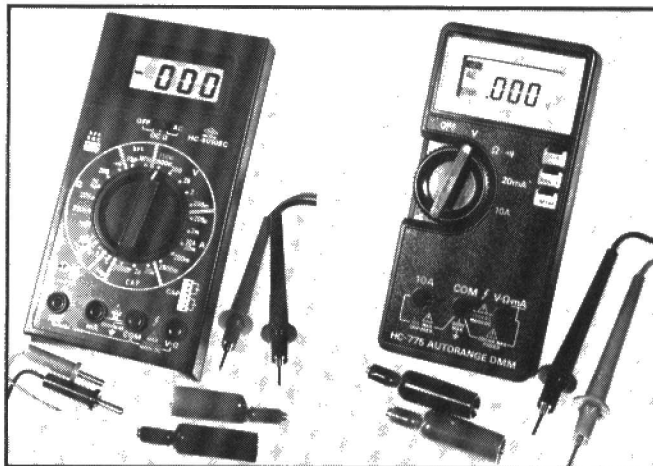
Capacitance measurement is provided in three ranges: 200 pF with resolution of 1 pF and accuracy of $\pm(1.5\% \text{ full scale} + 5 \text{ digits})$, $2\mu\text{F}$ with $0.001\mu\text{F}$ resolution and $\pm(2\% \text{ FS} + 5 \text{ digit})$ accuracy and $20\mu\text{F}$ with $0.01\mu\text{F}$ resolution, accurate to $\pm(2\text{FS} + 5 \text{ digits})$. Conductance is measured in the 200 ns range with a resolution of 0.1 ns and accuracy of $\pm(1.5\% \text{ reading} + 10 \text{ digits})$ and the temperature range is -20°C to $+137^\circ\text{C}$ with a resolution of 1°C and accuracy of $\pm 3^\circ\text{C} + 1 \text{ digit}$.

The model HC 775 is a pocket-sized auto-ranging digital voltmeter with many extra features including low and high

power resistance and AC/DC current measurement. It also has a memory mode, which can be set manually, and overload protection.

Other features of the HC 775 include $3\frac{1}{2}$ digit 10mm high LCD, auto-polarity and mode display, and LO BATT indication. The DC voltage range is 200mV, 2V, 20V, 200V, 1000V with $100\mu\text{V}$ resolution, while the AC voltage range is 2V, 20V, 200V, 750V with 1mV resolution. Accuracy is to $\pm(0.75\% + 1 \text{ digit})$.

Contact: Cirkit Distribution, Park Lane, Broxbourne, Herts EN10 7NQ. Tel: (0992) 444111.

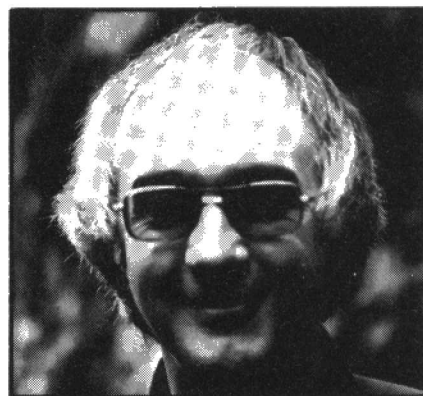


THE LEADING EDGE

BY BARRY FOX

RECORDING WITH ADDED DROP-OUTS

Record companies have found a way of protecting their investment. But what about the music.



WHILE the US State Senate and House of Representatives move closer to banning DAT hardware, unless it includes circuitry for the Copycode anti-code systems, the Japanese electronics industry is fuelling the argument that Copycoding spoils the sound of original recordings, as well as spoiling copies. Representatives of Matsushita, Pioneer and Toshiba went to Washington recently, to lobby politicians with tapes which simulate Copycode.

So what is Copycode?

Copycode was developed by CBS of America in 1982. It relies on doctoring the sound of all future gramophone records and compact discs so that matching sensor circuitry in a recorder switches it off when an attempt is made to copy the record.

The record companies object to people taping records at home. They fear the problem will worsen with the new digital audio tape format, DAT. This is already on sale in Japan and due in Europe and the USA at the end of 1987 or early 1988. DAT offers at least 2 hours of CD quality digital audio from a single cassette the size of a credit card; whereas conventional audio cassettes record a maximum of 120 minutes of analogue sound, with flip-over or autoreverse half way through.

In 1980 the Recording Industry Association of America asked 38 universities and research laboratories to develop a spoiler system which would stop people copying any record onto any tape recorder. As most engineers predicted, the request was futile. CBS did however develop the system now known as Copycode which can prevent a modified recorder taping from a sonically labelled record. The music on a record, as sold to the public, is doctored to remove a notch of frequencies. This notch is 300Hz wide, 60dB deep and centred on 3.84kHz. The Copycode sensor compares energy levels at this and adjoining frequencies.

In 1982, when CBS first developed Copycode, it was impossible to implement because there were already hundreds of millions of tape recorders in use without Copycode circuitry. But

with DAT such a young product, there is a chance to legislate and make Copycode circuitry an essential part of a DAT recorder. It would then be up to the record companies to notch the sound on any new vinyl LPs, compact discs or prerecorded tapes. Notching survives broadcast transmission.

As this would rob 7800 DAT recorders of their prime purpose, namely the ability to record from discs and broadcasts, the Japanese are predictably resisting!

Engineers do not dispute that the CBS system will work, most of the time recognising and refusing to record Copycoded music. What worries them is the unproven claim by from CBS that notching is "effectively inaudible". If the proposal is adopted, record companies will code recordings by passing them through a series of very sharply acting electrical filters. Apart from the obvious question of whether a sensitive ear will detect the missing frequencies, there is the added problem that sharp filters can introduce phase shifts into other frequencies. This may cause odd audible effects, especially in stereo.

CBS has several times previously fallen foul of audio critics. In the 70s the company's SQ quadraphonic surround sound system failed, because people did not like the results and questioned compatibility with stereo equipment. So did the CX system which reduced the background noise of LP discs when played on modified equipment, but sounded wrong on any ordinary gramophone. More recently CBS has been trying, without success, to persuade the BBC, IBA and European radio stations to adopt its FMX system. This reduces hiss noise on stereo broadcasts for people with modified receivers. But again there are questions on compatibility with existing radios.

CBS has demonstrated Copycode to British record company executives at EMI's Abbey Road studios in London and shown it to Common Market officials in Brussels.

But CBS has not yet demonstrated Copycode to hi fi journalists or record reviewers. If these groups rebel against Copycoding the record industry may end

up not only stopping home taping but deterring people from buying records as well.

"We are very apprehensive" admits the BBC's Engineering division "especially now that listeners' perception of high quality sound has been increased by compact disc. We would need convincing".

One group of studio engineers in a London studio – who were never asked to hear the CBS demonstrations – have run their own tests. They doctored one of their own recordings with a notch which exactly matched the CBS proposal. Expert ears heard it at once; on strings and female voices in classical music there was a subtle rounding off of the sound, with muddying of the stereo image. The studio test filtering was done digitally. Analogue brickwalling, with additional phase shifts, could be more noticeable.

Already some engineers have worked out how to defeat Copycode, by artificially generating noise, filtering out a band around 3.84kHz, and using an automatic gain control to track the level of the music signal so that the notch is filled with noise which matches the lost signal. Hence the music industry's campaign to make the sale of anti-Copycode devices punishable by law.

The IFPI, International Federation of Phonogram and Videogram Producers, is the music industry trade body which is spearheading the lobby to get the Copycode requirement for DAT written into American and European law. The IFPI has pronounced blandly that Copycode "is inaudible and does not interfere with normal playback". But the IFPI has also failed to demonstrate Copycode to the press and reviewers.

In March the IFPI issued a statement which suggested that both Philips and Thorn-EMI were backing Copycode. So I asked both Philips and Thorn-EMI the obvious question, were they satisfied that the use of the Copycode system would do nothing whatsoever to impair audio quality and that the Copycode notch is inaudible in the true and unqualified sense of the word.

Continued on Page 33

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EDUCATIONAL ROLE CALL

THE importance of the interactive roles of both electronics and education has frequently been asserted by my editorial predecessors, and I strongly endorse their sentiments. Whilst I maintain that electronics is fun, and can be enjoyed for its own sake without necessarily being a means to an end, its educational value cannot be over emphasised.

Electronics is a cutting edge on the technological spearhead, and although students of electronic techniques and applications may not directly make use of the formally taught information, or ultimately pursue an electronics career, the knowledge gained, and the analytical outlooks acquired through it can be of considerable assistance in the understanding of other disciplines.

In conjunction with our many expert authors, PE has been active in disseminating knowledge about electronics and innumerable allied subjects for over two decades. Some of our contributing authors are already employed in education and industry, and we know the benefit that readers from all walks of life derive from their articles.

Now, starting with this issue, we take our involvement a logical step forward, introducing a new series of articles that will be published over the next few months. These have been written by Tim Pike, a deputy head master who is well respected for his abilities and achievements in bringing electronics and computing to the classroom. They basically consist of projects specifically aimed at those taking G.C.S.E. exam courses, but the subject matter and presentation style will also be of considerable value to those whose interest in electronics is less formally academic. Other teachers, who may perhaps be in the early stages of setting up classroom electronics facilities, should benefit from the series as well.

It is also believed that many more trained educators, whether in schools, colleges, universities, or industry, can and should contribute both general interest and constructional articles that can be directly related to the needs of students and tutors alike. It is equally important that those pioneering the advance of the technological spear should similarly ensure that their research knowledge becomes part of the educational curriculum. Consequently, if you are an instructor or researcher, we should be pleased for you to share your knowledge with our very wide readership by submitting articles or projects for possible inclusion in future issues. Even if you have doubts about your writing capabilities, you may well have good ideas for subjects that you feel would benefit yourself and others, or strong beliefs about the inter-relationship between technology and education. Either way, don't hide your expertise, share it.

Only through good education and a broad interchange of ideas can the inheritors of the spear be better equipped to maintain its essential advance.

THE EDITOR

PLEASE NOTE OUR NEW ADDRESS

OUR OCTOBER 1987 ISSUE WILL BE ON SALE FRIDAY, SEPTEMBER 4th 1987 (see page 2)

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TEACHER TIMER

BY TIM PIKE

The first of a series of articles aimed at giving Secondary School pupils ideas for GCSE projects

Timers make versatile and useful projects, which can be very simple or quite complex. You takes your pick, and get into RC time constants, Schmitt triggers and 741 op-amps.

If you are a fourth or fifth year pupil in a Secondary School and you are studying one of the new examinations in Electronics then you may shortly be thinking about a suitable examination project. For the older readers, some of whom will be parents or teachers of this group, you have a part to play in this as well.

The main thrust of the new examination courses is in learning how to apply knowledge in practical situations rather than concentrating on the acquisition of knowledge for its own sake. Young people do not have the same difficulty in adapting to this change because they have never known anything else. Those of us who experienced a very different regime at school need to work harder at adapting. It is very important though that we make this effort and keep up with the current trends. Pupils, no matter how confident, still need guidance and reassurance with their school work. This is our part in the process. So how does this relate to Electronics?

Over the next few months many schools and colleges throughout the country will enter a new "Season" of the academic year. This is the project season, when school laboratories and workshops are turned upside-down; students' bedrooms are redesigned to house test benches and many of us mad teachers stay long hours at our beloved schools helping some poor boy or girl to wrestle with a recalcitrant soldering iron or to replace a blown BC108 for the tenth time!

Although there are differences in the detail of project requirements according to which of the new Examination Boards your local school uses, the necessity for a project is common to all.

I have chosen to commence this series with a design for a simple timer. This type of circuit is usually included amongst any list of suitable projects.

There are also a great many possible avenues for circuit design, ranging from the very simple to the more sophisticated, the latter being suitable for the most able candidates to work on.

TIMING MECHANISMS

In all simple timing circuits of this type, the time delay is created by a

Tim Pike is Deputy Headmaster of the Ramsden School for Boys in Orpington, Kent. He has taught Electronics to 'A' level standard for thirteen years. Each year there are on average eight 'A' level candidates, twelve 'A/O' level candidates and sixty GCSE (previously 16+) candidates. In all cases there are always some girls included in the groups from the neighbouring Ramsden School for Girls. This is Equal Opportunities in Action!

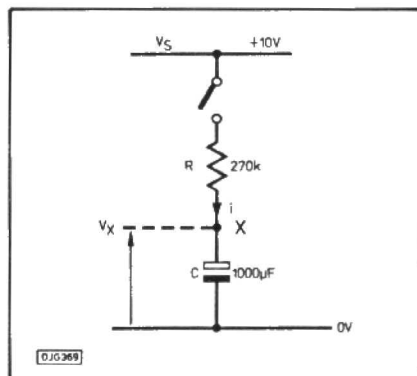


Fig.1. Simple delay circuit

resistor and a capacitor connected in series. (Fig.1.)

The voltage at point X starts from 0V when the switch is closed. As the current flows through resistor R, charge builds up in the capacitor C. The voltage at point X rises at the same rate as the charge stored in the capacitor. (Fig.2.) The current flowing into the capacitor starts at a maximum value, given by

$$\frac{V_s}{R}$$

and decreases as the capacitor charges. (Fig.3).

The time constant of the resistor-capacitor combination is defined as the product of R and C. R must be measured in ohms; C must be measured in farads. The result of multiplying the two then gives a value directly in seconds.

The significance of the time constant is that in this period of time the voltage across the capacitor rises to 63% of its maximum (aiming) voltage. In the next time constant period it rises by a further 63% of the difference between the voltage at the beginning of the period and the aiming voltage, and so on.

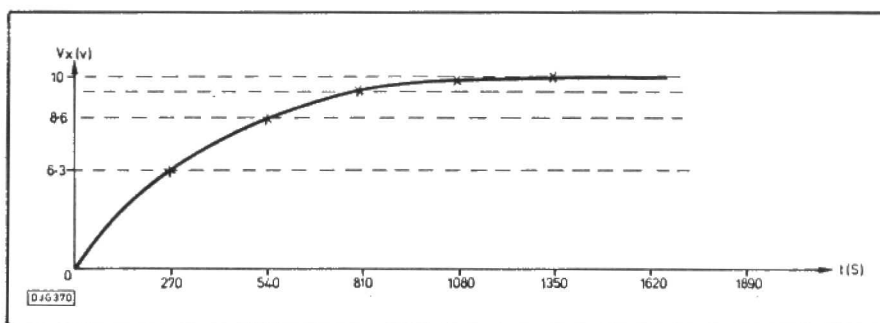


Fig.2. Capacitor voltage charging rate

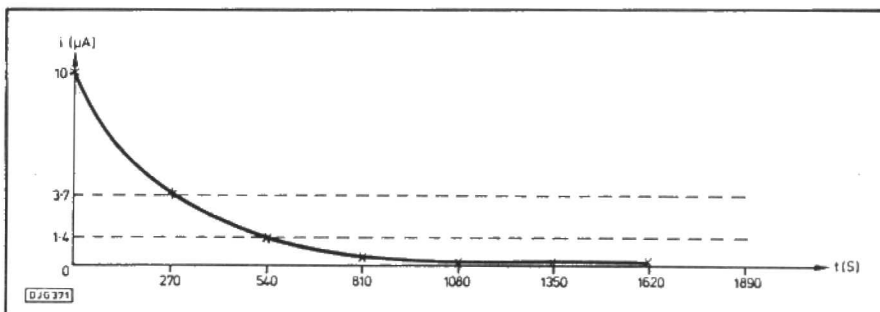


Fig.3. Current flow decrease as capacitor charges

If the supply (aiming) voltage is 10V, $R = 1M\Omega$ and $C = 1\mu F$ then table 1 gives the results:

Time (s)	Voltage (Vx)	Charging Current (μA)
0	0V	10.0
1	6.3V	3.7
2	8.6V	1.4
3	9.5V	0.5
4	9.8V	0.2
5	9.9V	0.1

Table 1

It can be seen that after only five time constants, the voltage has risen to within 1% of its final value. Similarly the current has fallen to practically zero.

USING THIS PRINCIPLE

Now that we have produced a voltage which rises in a predictable way (although not linearly) over a period of time we can use this to trigger a switching circuit of some sort. There are many possibilities.

THE SINGLE TRANSISTOR SWITCH

If we connect the rising voltage across the capacitor directly to the input of a transistor, being used in common emitter configuration, then we have a circuit like the one in Fig. 4.

This circuit will give a delay of only about 20 seconds before the output device comes on, in this case a standard l.e.d. The time constant (RC) is 270s. and so five time constants would be over 22 minutes. Why then is the actual delay only 20 seconds?

The reason is, of course, that the

transistor requires a base voltage of only around 0.7V to switch on. In fact in this circuit the capacitor will never be allowed to charge to more than this point. The base-emitter junction of the transistor behaves like a forward biased diode and holds the voltage at around 0.7V. So how do we calculate the anticipated time delay in this circuit?

TIMING RELATIONSHIPS

The accurate method requires mathematics well beyond the average GCSE pupil. For teachers and other readers, the method depends upon a knowledge of the equation of the charging curve of the capacitor. The relationships are as follow:

$$V_t = V_s (1 - e^{-\frac{t}{RC}})$$

Where V_t = Voltage at any time t (s)

V_s = Supply (aiming) voltage.

e = base of natural logarithms.

Rearranging this equation to find t from known values of V_t , V_s , R and C gives:-

$$t = -RC \ln(1 - \frac{V_t}{V_s})$$

So, for the circuit of Fig. 4, if $V_t = 0.7V$ (the voltage at which the transistor switches on), then

$$t = 19.6s$$

This assumes that while the capacitor is charging no current flows into the base of the transistor. In practice, a very small current will flow into the transistor and therefore the actual time recorded may be slightly longer.

Another approach is to make use of the graph (Fig. 5). If we draw the whole

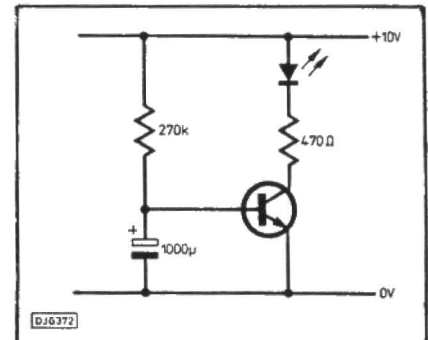


Fig. 4. Delayed action transistor switch

graph up to five time constant periods, and then look to see how much time has elapsed when the voltage reaches the threshold. This will give a reasonably accurate idea of the delay.

LONGER TIME DELAYS

There are practical problems with increasing the values of R and C to produce longer time delays. Very large electrolytic capacitors are 'leaky' and may not hold their charge for long enough. Very large resistors limit the current which ultimately flows into the base of the transistor and may eventually be too large to pass enough current to turn on the transistor.

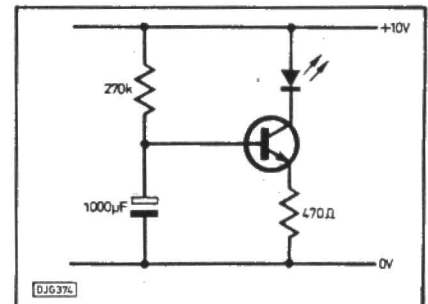


Fig. 6. Extended delay transistor switch

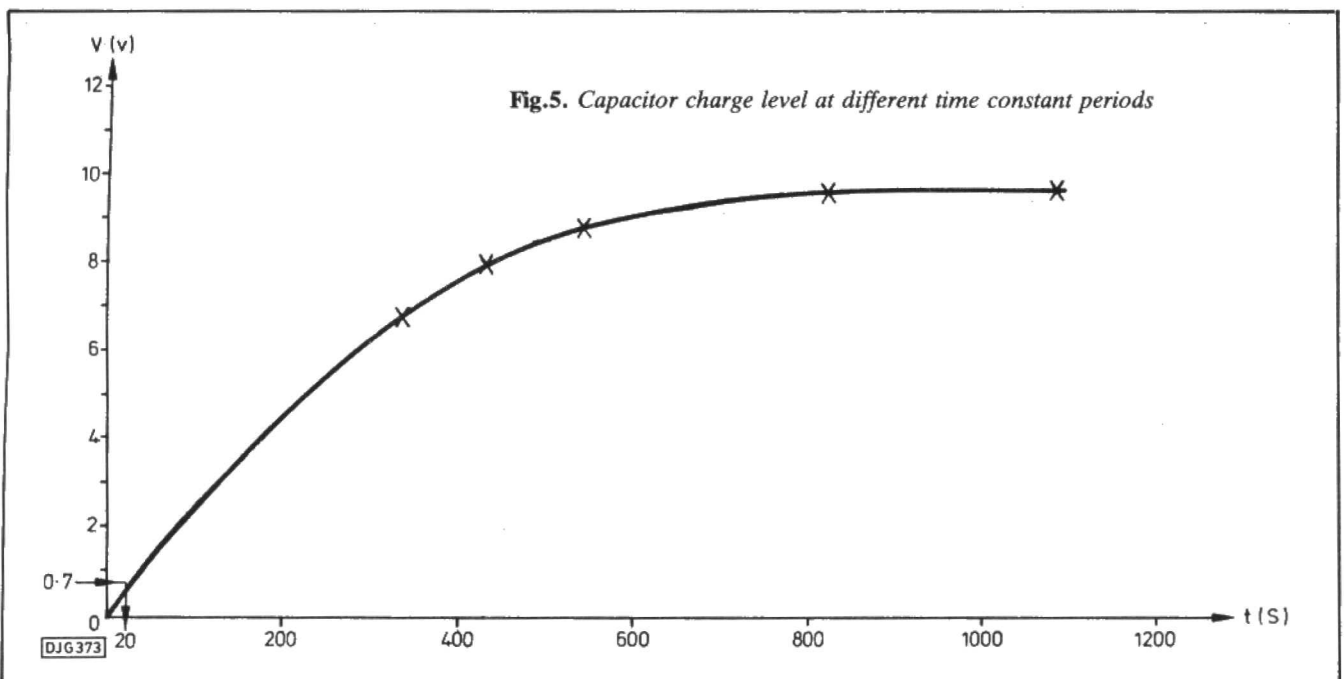


Fig. 5. Capacitor charge level at different time constant periods

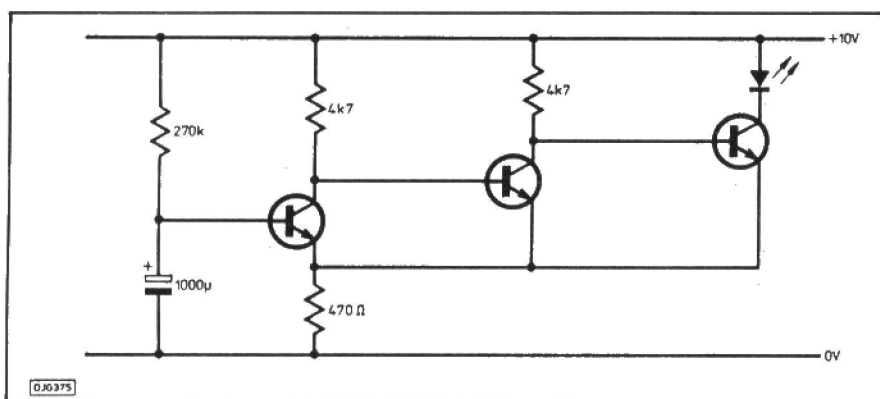


Fig.7. Delayed action Schmitt Trigger

Another method is to make more use of the whole charging curve. If the circuit output is changed to include an emitter resistor then the threshold voltage will rise to around 8V before the transistor turns on. (Fig.6). As can be seen from Fig.5 this increases the delay to around 7 minutes (435s.).

SHARPER SWITCHING ACTION

The next problem to consider is how to overcome the gradual switching which this simple circuit exhibits. To do this we look at providing a second transistor connected to form a Schmitt Trigger. (Fig.7). This produces an unwanted inversion of the output and so a third transistor is added to correct this.

PROVISION OF AUDIO OUTPUT

The simplest form of audio output is an active audible warning device. These can be operated directly from a d.c. supply. Unit cost is usually no more than for a small loudspeaker. The output transistor must be of a type capable of

driving the a.w.d. but currents as low as 18mA are acceptable.

A FINAL DESIGN

For the final design I would suggest a move to the use of a voltage comparator based around a 741 operational amplifier. (Fig.8). This has a number of advantages over a single or even a double transistor switch. Firstly, larger values of R and C can be used to obtain longer delays. Secondly, the switching threshold can be set by another pair of resistors, R1 and R2, acting as a potential divider. The gain of the 741 is very high when used in open loop mode and therefore the switching action is very positive. Although the 741 would drive many output devices directly, the addition of a single stage transistor switch driving a general purpose relay with both normally open (NO) and normally closed (NC) contacts ensures that currents in excess of 1A can be provided. If the relay is a mains type then the possibilities are almost endless.

In this instance R has been split into two parts, R3 and VR1. This allows variable timing constants to be set by varying the resistance of VR1. R3 acts as a safety resistor to protect VR1 when it is set at low resistance.

A diode is included in parallel with the relay coil in order to protect the transistor from the undesirable effects of electromagnetic induction (back emf) as the relay contacts open and close. Those students with a reasonable knowledge of physics will appreciate how and why this problem occurs. The diode in reverse bias to the power supply acts as a low resistance path to reverse currents. This prevents high voltages from building up on the collector of the transistor.

The time delay for this circuit would be given from:-

$$1 - e^{\frac{-t}{(VR1 + R3)C}} = \frac{R2}{R1 + R2}$$

i.e.

$$t = (VR1 + R3)C (\ln(R1 + R2) - \ln R1)$$

$$\text{If: } R1 = 10k\Omega, R2 = 100k\Omega, R3 = 1k, \\ VR1 = 1M\Omega, C = 100\mu F$$

then a time delay of 40 minutes ought to be produced. In practice, this delay is recorded as being in excess of 2½ hours! Certainly the timing becomes very unpredictable with such large values of resistor and capacitor.

A more reliable timing response is obtained if VR1 is kept to 100k. The range of delays now available is from about 5 seconds to 8 minutes.

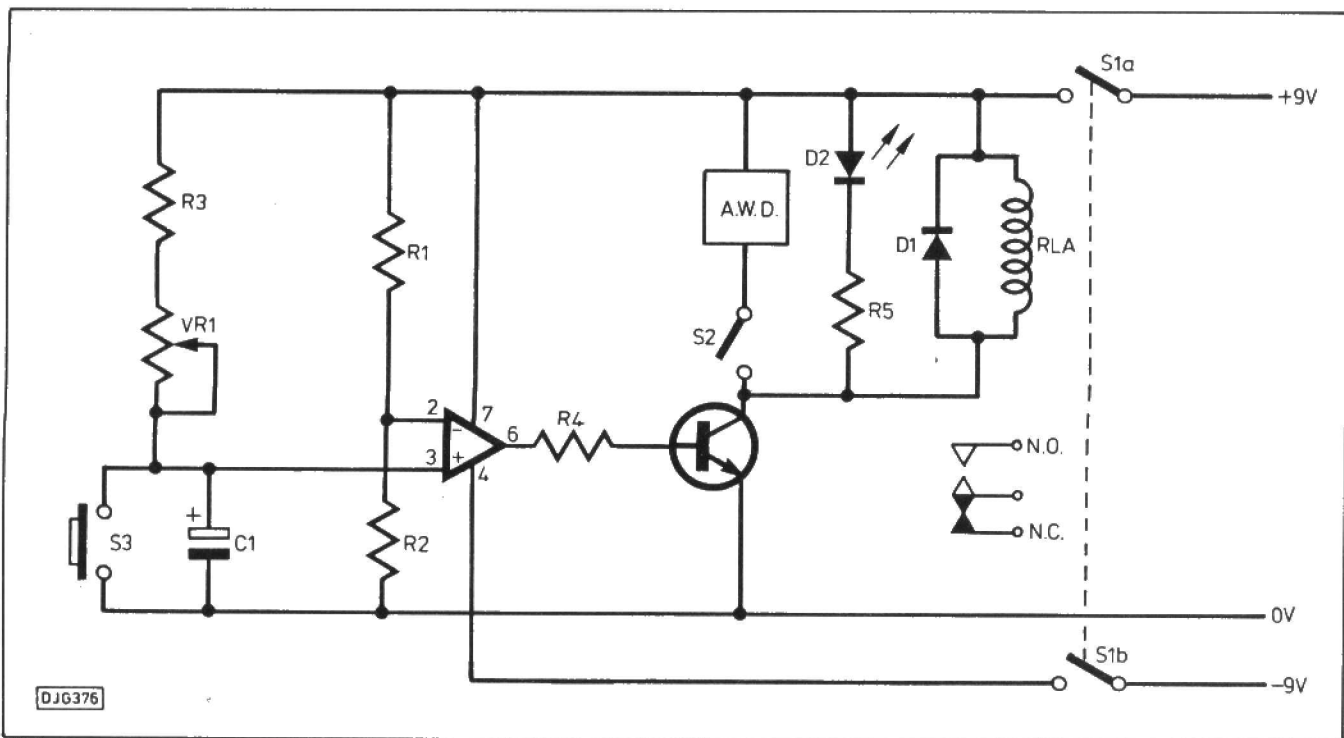


Fig.8. Practical delayed action timer circuit

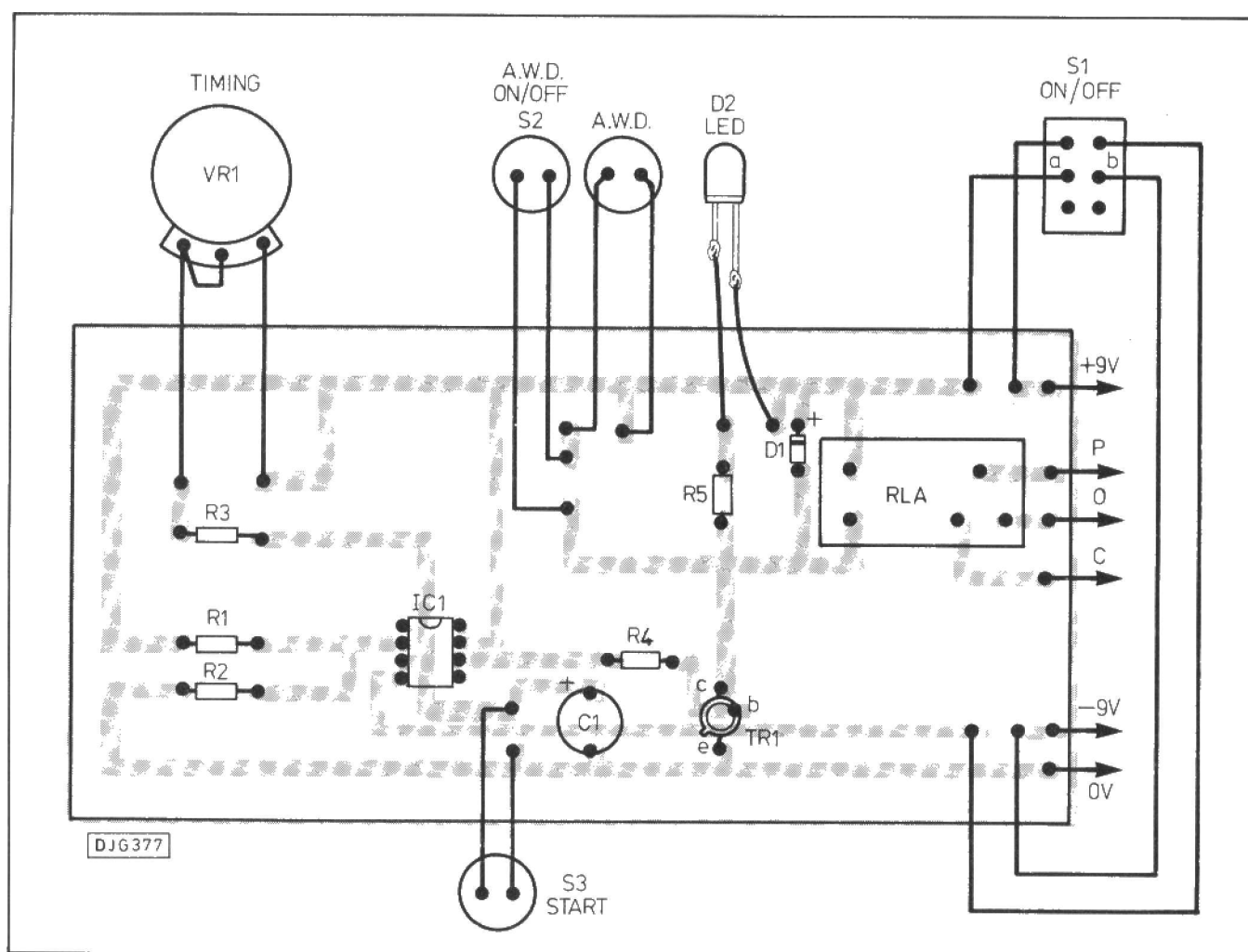


Fig.9. Suggested printed circuit board layout and wiring details

DUAL POWER SUPPLIES

Although it is possible to design this circuit to operate from a single voltage rail of between 5V and 15V, the 741 op-amp does not work well under these conditions. There are other op-amps that will produce reliable output voltages from a single rail supply but these are not found within a typical GCSE course. Indeed one feature of op-amps which GCSE students are expected to know is that they *require* a dual supply. In order then not to confuse, I have incorporated a dual supply of $\pm 9V$ into the final design. Two PP3 type batteries work very well indeed.

CONSTRUCTION TECHNIQUES

Pupils may choose one of a variety of constructional techniques. Good quality bread boards and wire-wrapping are acceptable if appropriate to the particular project. Some examination boards would expect to see the skills of soldering, component-layout and testing facilities incorporated into the project. Certainly the use of copper stripboard or simple printed-circuit design are the favourite methods. The choice and provision of a container with the appropriate external controls is sometimes but not always necessary.

RESISTORS

R1 10k
R2 100k
R3,R4 1k (2 off).
R5 470R
All $\frac{1}{4}$ Watt carbon 5%

POTENTIOMETER

VR1 100k lin rotary

CAPACITORS

C1 100 μ F 16v. electrolytic radial.

SEMICONDUCTORS

IC1 741 operational amplifier.
TR1 BFY51 or BFY52 transistor.
D1 1N4148 silicon diode.
D2 Light emitting diode

MISCELLANEOUS

S1 DPST miniature toggle
S2 SPST latching push switch, or SPST toggle.
S3 SPST non-latching push-to-make.
AWD Active audible warning device.
REL 1 SPCO p.c.b. mounting relay suitable for mains switching (if required), 9V min coil.

Box to suit, PP3 battery clips (2 off), knob, wire, solder, printed circuit board (see text).

For this project I have chosen to use a printed circuit board design. One possible implementation of this is given in Fig.9. It should be stressed however that pupils should be encouraged to develop their own designs. The best pupils will certainly cope with printed circuit designs once given the basic techniques of how to go about it.

TESTING

Testing as part of a properly conducted

evaluation is a very important feature of the projects. Pupils should be encouraged to follow a logical progression of tests. In the main this will mean taking voltage readings at all the important points in the circuit.

In this circuit, these points would include the data shown in Table 2.

If necessary the reading at the cathode of D2 and either side of the switches may additionally be required. Also as part of the testing sequence timing

TEACHER TIMER

measurements can be made. These can subsequently be used for calibration marks around VR1 on the box.

CONCLUSION

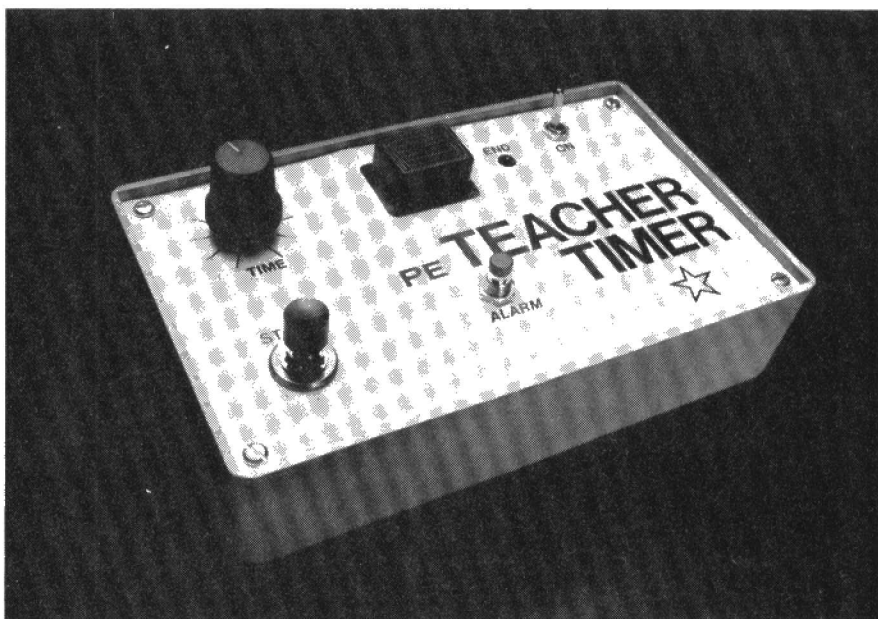
There is a great deal of basic electronics in a project of this type. Fundamental ideas about the behaviour of resistors, capacitors and transistors in switching circuits are well explored. The very large range of abilities of pupils is catered for by so many levels of circuit design. The circuits given need not, and should not, be taken as prescriptive. The intention is to make suggestions and to give pointers to ways in which the original theme might be tackled. It is very important that pupils are given the opportunity to practice circuit design and construction prior to taking the actual practical examination assignment. Subject to finance, schools should be able to organise this for themselves. It is hoped that this series will encourage and help those pupils and teachers in schools where Electronics is still very new to put away the text books and take out the soldering irons. Good luck! **PE**

NEXT MONTH:

Tim Pike describes an electronic lock which incorporates basic logic functions, principles of linking digital and analogue devices, sequencing the inputs, latching the output, and detecting "trial and error" attempts at opening the lock.

TYPE	TEST	EXPECTED READING
Voltage reading compared to OVline	1. Voltage rails (x 3)	+9V, OV, -9V
	2. Inputs to IC1. (x 2)	+8.1V (pin 2), OV rising (pin 3) to 9V
	3. Output of IC1	OV switching suddenly to 9V (pin 6)
	4. Collector of T1	9V switching suddenly to 1V or less
Continuity	5. Relay switch contacts.	0Ω or ∞ according to state of relay.

Table 2.



BI-PAK BARGAINS

Pak No	Qty Description	Price	Pak No	Qty Description	Price	Pak No	Qty Description	Price
RESISTORS								
VP1	300 Assorted Resistors, mixed values and types	£1.00	VP4167	4 74167 Synchronous Decade Rate Multipliers	£1.00	VP226	20 DIN Casses Sits, metal 2-8 pin 180°/240°/360° mixed	£2.50
VP2	300 Carbon Resistors 1/4-1/2 watt, pre-formed, mixed	£1.00	BP4174	4 74174 Hex D-Type Flip-Flops	£1.00	VP227	18 DIN In-line Sits, plastic 2-8 pin 180°/240°/360° mixed	£2.50
VP3	200 1/4 watt Min. Carbon Resistors, mixed values	£1.00	VP4181	4 74181 Arithmetic Logic Unit/Function Generators	£1.00	VP228	10 C15 Computer Cassette Tape, leadless	£3.00
VP4	200 1/2 watt Resistors, mixed values and types	£1.00	VP4193	4 74193 Synchronous Up/Down Dual Clock Counters	£1.00	VP229	10 Cassette Tape, 2 x 30 min, low noise	£3.00
VP6	50 Wirewound Resistors, mixed watt values	£1.00	VP421	Binary clear	£1.00	VP230	10 Cassette Tape, 2 x 45 min, low noise	£3.00
VP121	1 50k Resistance Box, 36 values 50ohm-1 Kohm	£4.75	VP4279	4 74279 Dual S-R Latches	£1.00	VP231	1 Cassette Head Cleaner Tape, non abrasive, in case	£1.00
VP142	50 Precision Resistors, 1% tolerance	£1.00				VP232	1 Cassette Head Cleaner/Demagnetizer, in case	£2.00
VP181	100 1 and 2 watt Resistors, assorted values	£1.00				VP233	1 Revolving Cassette Rack, holds 32, smokley perspex	£2.50
CAPACITORS								
VP5	200 Assorted Capacitors, all types	£1.00	BPX6	1 TTL Data Book 74 Series, including "LS". Complete with Pin out Diagrams, 7400-74670, TTL Interchangeability Guide, Selection Guide and Explanation of Function Tables	£1.00	VP234	1 Demagnetizer Curved Probe, 240V AC	£3.00
VP6	200 Ceramic Capacitors, Min. mixed values	£1.00				VP235	1 VHS Video Head Cleaner Cassette Wet type	£4.00
VP8	100 Mixed Ceramic Disc, 68pF-015pF	£1.00				VP236	1 Betamax Video Head Cleaner Cassette, Wet type	£4.00
VP9	100 Assorted Polyester/Polyethylene Capacitors	£1.00				VP237	1 Universal Ni-Cad Battery Charger, AA-HP11-HP2, PP3	£3.00
VP10	60 0.220 Capacitors, Metal foil, mixed values	£1.00				VP238	4 AA Ni-Cad Batteries, 1.25v 500 mA C/R mA	£4.00
VP11	50 Electrolytics, all sorts	£1.00				VP239	2 C-HP11 Ni-Cad Batteries, Rechargeable	£3.50
VP12	40 Electrolytics, 47mf-150mf, mixed volts	£1.00				VP240	2 D-HP2 Ni-Cad Batteries, Rechargeable	£4.00
VP13	30 Electrolytics, 150mf-100mf, mixed volts	£1.00				VP241	2 0HP2 Light Dependent Resistor	£1.50
VP15	25 0.125v Min. Layer Metal Caps	£1.00				VP242	4 Tr-colour LEDs, 5mm Dia, 5mA 2v R.G.Y.	£1.00
VP146	25 Solid Tantalum Caps, mixed values	£1.00				VP243	3 Tr-colour LEDs, Rectangular 5mm R.G.Y.	£1.00
VP180	25 Tantalum Bead Caps, assorted values	£1.00				VP244	1 High Power Piezo Electric Siren, Emits Expanding warbling sound. Ideal alarm. White plastic body with mounting bracket. Power 12v DC 15mA. Output 100db (A) at 1m typ. Freq. 2.5KHz. Size 57 x 42 x 37mm	£6.00
VP182	4 1000uF 50v Electrolytics	£1.00				VP245	1 Automatic Lighting Switch, Photoelectric, weatherproof. Switches lights or equipment "ON" at dusk "OFF" at dawn. Loads up to 3A at 240v AC. Size 50 x 45mm	£5.00
VP182	30 Min. Electrolytics, mixed values, 47mf-1000mf 6/16v	£1.00						
VP193	6 Sub Min. Electrolytics, 2 x 1000/2200/3300mf 10/16v	£1.00						
IN SERIES SALE "ROCK BOTTOM" PRICES								
VP223	50 Ass't TTL IC's, "ALL GATES" new & coded our mix 7400-7453	£8.00						
VP224	100 Ass't TTL IC's, "ALL GATES" new & coded our mix 7400-7453	£10.00						
VP2413	4 7413 Dual NAND Schmitt Trigger 4-Input	£1.00						
VP2440	4 7440 Dual 4-Input, Positive-Nand Buffer	£1.00						
VP2470	4 7470 And-gated Postivied-edge-triggered	£1.00						
	Flip-Flop with preset	£1.00						
VP2480	4 7480 Gated full Adder	£1.00						
VP2481	4 7481 16-Bit Random Access memories	£1.00						
VP2480	4 7480 Decade Counter	£1.00						
VP2481	4 7481 8-Bit Shift Register	£1.00						
VP2482	4 7482 Divided by 12 Counter	£1.00						
VP2483	4 7483 4-Bit Binary Counter	£1.00						
VP2484	4 7484 4-Bit Shift Register	£1.00						
VP2485	4 7485 4-Bit Shift Register	£1.00						
VP2486	4 7486 4-Bit Shift Register	£1.00						
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VP2497	4 7497 4-Bit Shift Register	£1.00						
VP2498	4 7498 4-Bit Shift Register	£1.00						
VP2499	4 7499 4-Bit Shift Register	£1.00						
VP2500	4 7500 4-Bit Shift Register	£1.00						
VP2501	4 7501 4-Bit Shift Register	£1.00						
VP2502	4 7502 4-Bit Shift Register	£1.00						
VP2503	4 7503 4-Bit Shift Register	£1.00						
VP2504	4 7504 4-Bit Shift Register	£1.00						
VP2505	4 7505 4-Bit Shift Register	£1.00						
VP2506	4 7506 4-Bit Shift Register	£1.00						
VP2507	4 7507 4-Bit Shift Register	£1.00						
VP2508	4 7508 4-Bit Shift Register	£1.00						
VP2509	4 7509 4-Bit Shift Register	£1.00						
VP2510	4 7510 4-Bit Shift Register	£1.00						
VP2511	4 7511 4-Bit Shift Register	£1.00						
VP2512	4 7512 4-Bit Shift Register	£1.00						
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VP2514	4 7514 4-Bit Shift Register	£1.00						
VP2515	4 7515 4-Bit Shift Register	£1.00						
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VP2530	4 7530 4-Bit Shift Register	£1.00						
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VP2532	4 7532 4-Bit Shift Register	£1.00						
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VP2541	4 7541 4-Bit Shift Register	£1.00						
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VP2559	4 7559 4-Bit Shift Register	£1.00						
VP2560	4 7560 4-Bit Shift Register	£1.00						
VP2561	4 7561 4-Bit Shift Register	£1.00						
VP2562	4 7562 4-Bit Shift Register	£1.00						
VP2563	4 7563 4-Bit Shift Register	£1.00						
VP2564	4 7564 4-Bit Shift Register	£1.00						
VP2565	4 7565 4-Bit Shift Register	£1.00						
VP2566	4 7566 4-Bit Shift Register	£1.00						
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VP2568	4 7568 4-Bit Shift Register	£1.00						
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VP2570	4 7570 4-Bit Shift Register	£1.00						
VP2571	4 7571 4-Bit Shift Register	£1.00						
VP2572	4 7572 4-Bit Shift Register	£1.00						
VP2573	4 7573 4-Bit Shift Register	£1.00						
VP2574	4 7574 4-Bit Shift Register	£1.00						
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VP2590	4 7590 4-Bit Shift Register	£1.00						
VP2591	4 7591 4-Bit Shift Register	£1.00						
VP2592	4 7592 4-Bit Shift Register	£1.00						
VP2593	4 7593 4-Bit Shift Register	£1.00						
VP2594	4 7594 4-Bit Shift Register	£1.00						
VP2595	4 7595 4-Bit Shift Register	£1.00						
VP2596	4 7596 4-Bit Shift Register	£1.00						
VP2597	4 7597 4-Bit Shift Register	£1.00						
VP2598	4 7598 4-Bit Shift Register	£1.00						
VP2599	4 7599 4-Bit Shift Register	£1.00						
VP2600	4 7600 4-Bit Shift Register	£1.00						

A primer on the world and workings of Musical Instrument Digital Interface, the international standard which allows one pair of hands to program an orchestra.

THE MIDI INTERFACE

BY THE PROF

Band in a box

With all the huge advances in electronic musical instruments over the last few years, it might seem strange that many regard the MIDI interface as the most significant advance of all. After all, it is merely a means of communicating information between one instrument and another (MIDI stands for Musical Instrument Digital Interface), and it does not improve the sound of an instrument one iota. I suppose that to some users of electronic musical instruments the MIDI interface is of no use whatever, and a pianist who uses an electronic piano might never notice the MIDI sockets at the back of the instrument, or ever need to! On the other hand, for someone who is trying to stretch the abilities of modern instruments to their limit, the MIDI interface offers an easy means of achieving this.

There is certainly scope for connecting various instruments together via their

MIDI sockets, and achieving things that would otherwise be impossible. However, it is probably the addition of a MIDI controller of some kind to the system that really brings things to life, and adds a new dimension to the system. Purpose built MIDI controllers are produced, but are relatively little used. A home computer plus MIDI interface and suitable software is a more popular choice, and one which can offer immense power and versatility. Computer control offers a variety of possibilities. Real-time sequencing is possible, with the controller acting rather like a tape recorder, or with the more sophisticated systems, even operating as a sort of pseudo multi-track tape recorder. So called step-time sequencing is the other main option. With a set up of this type the music is programmed into the computer and then played by the computer. This is disparagingly called

the "look no hands" method by some accomplished musicians, but it does have its merits. It enables those of limited playing ability to try out ideas which might otherwise be impossible for them to tackle unaided. It can be a quicker and more convenient way of doing things for some accomplished players, and it can be of immense value in musical education.

CURRENT LOOP

There are two sides to the MIDI standard: the hardware and the software. The idea of the MIDI interface is that it provides a common means of communications between instruments from different manufacturers. The hardware is fully standardised and any MIDI interface can exchange data properly with any other MIDI interface. The software is standardised up to a point, and note values sent from one instrument, for example, should be properly interpreted by any MIDI instrument that receives them. The MIDI system was designed to accommodate a wide range of different types of equipment, including such things as effects units and mixers. It was left to manufacturers to more or less design their own codes for more specialised applications, but most types of equipment are accommodated within the standard codes. In general, sending one of the more obscure MIDI

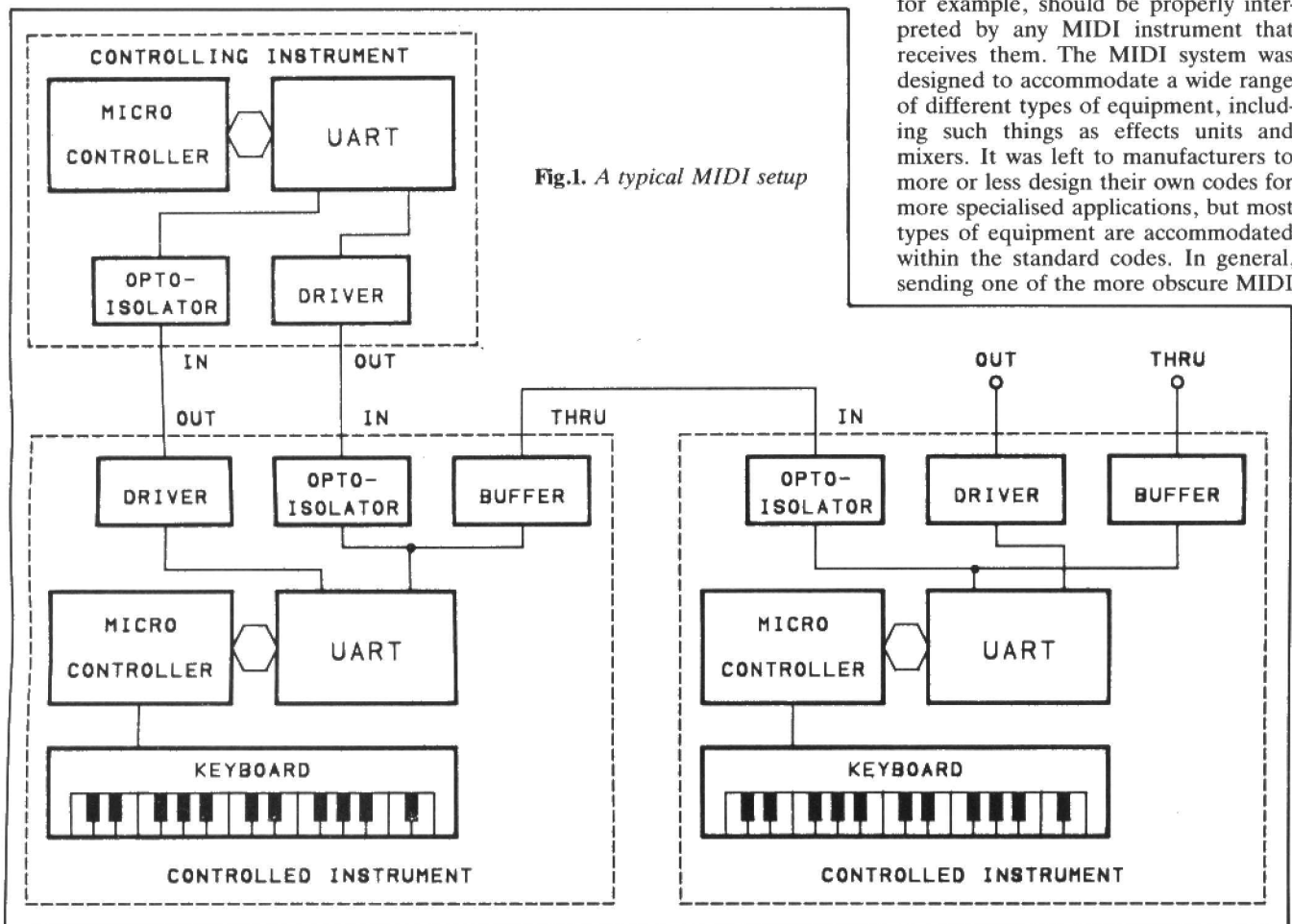


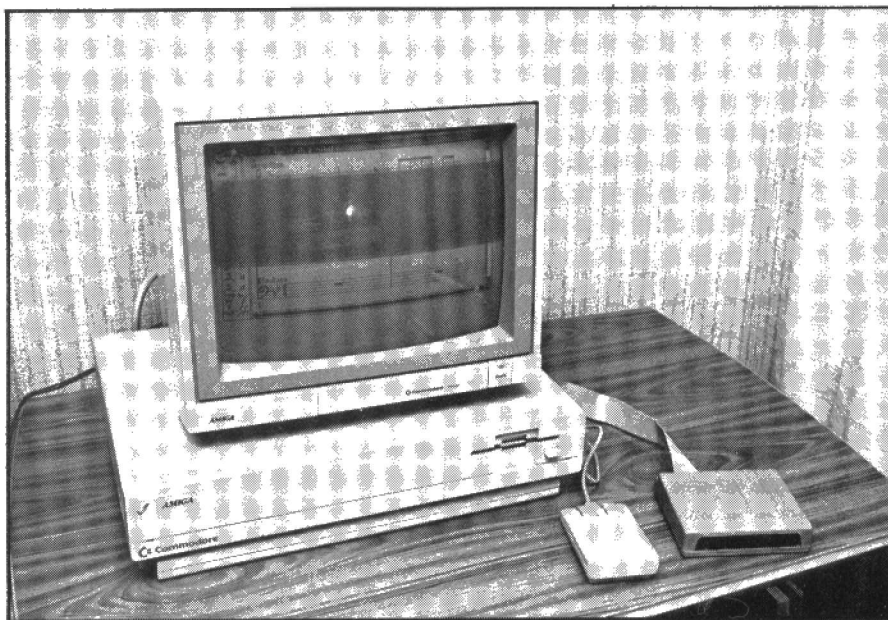
Fig.1. A typical MIDI setup

instructions to an instrument will not result in a malfunction, but if it is not within the repertoire of the equipment, or is irrelevant to it, the instruction will just be ignored.

We will consider both the hardware and software aspects of the MIDI standard in this article, and we will start with the hardware. There is nothing very complicated about the MIDI system as far as the electronics is concerned, and it is basically just an asynchronous serial system, much like the ordinary computer RS232C standard in many ways. There are some important differences though. The first point to note is that the baud rate is 31.25 kilobaud, which is not a standard RS232C baud rate. It is substantially higher than the maximum (normal) RS232C baud rate of 19.2 kilobaud. In fact the MIDI system did originally operate at 19.2 kilobaud, but before being launched commercially it was augmented to the current rate. This was done to give better synchronization in a multichannel system. However, as 31.25 kilobaud only represents about 3000 bytes per second, and MIDI commands are normally in three byte groups, with a large number of channels being sequenced there can still be a small but possibly significant delay between a command being sent to the first and last channels.

Although 31.25 kilobaud is not in the normal repertoire of an RS232C interface, it may in fact be within the capabilities of the hardware. In order to get the equipment to operate at this speed it would almost certainly be necessary to have a fairly detailed knowledge of the computer's hardware though, and it will not be feasible with many computers. The reason for this apparently rather odd baud rate is that 31250 is equal to 1 million divided by 32. This enables the clock signal for the serial interface chip to be easily derived from an oscillator based on standard 1, 2, 4, or 6MHz crystals.

The unusual baud rate is not the only way in which the MIDI standard departs from the RS232C norm. MIDI operates with opto-isolated inputs and a sort of current loop style arrangement. The classic MIDI output stage is an open collector output having current limiting at 5 milliamps, and this drives the l.e.d. at the input of a MIDI interface. Obviously the open collector output is not the only valid type though, and any output stage which will give about 5 milliamps or so of drive current and a signal of the correct polarity can be used. Provided the baud rate problem can be overcome, there would probably not be too much difficulty in producing an add-on to give suitable drive characteristics and an opto-isolated input for MIDI use. This approach seems to be little used in practice though, although it is the usual method of MIDI interfacing with the Commodore Amiga computer.



A Commodore Amiga plus Datel MIDI interface. The latter connects to the serial port, and provides MIDI "IN", "THRU", and three "OUT" sockets

There is nothing out of the ordinary about the word format. This is the most common one of one start bit, eight data bits, one stop bit, and no parity. This can be handled by every asynchronous serial device that I have encountered.

INTERCONNECTIONS

MIDI inputs and outputs are taken to separate sockets, and both are 5 way (18 degree) DIN types. There is an additional type of MIDI port, the "thru" socket. As its name suggests, this simply couples any signal received on the MIDI input through to a buffered output. Not all MIDI equipment has all three types of socket. In particular, "thru" sockets are often absent on controllers and add-on MIDI interfaces for computers. The main point of the "thru" sockets is to permit a single MIDI output to drive two or more instruments using the daisy-chain method of connection. A "thru" socket on a controller has no obvious application.

Some controllers and computer MIDI interfaces have several output sockets. This can be where two or more totally independent MIDI outputs are provided, and a large number of instruments can then be controlled. In most cases a single MIDI output is adequate to control all the instruments that will ever be put into the system, and few controllers offer separate outputs. It is much more common for a single MIDI output to be available at several sockets which are effectively connected in parallel (although they generally have separate output stages). This enables the so called "star" method of connection to be used. In other words, each instrument is driven from a separate output on the controller, rather than stringing them together in a daisy-chain arrangement.

There can be definite advantages to the "star" method of connection. Not all MIDI equipped instruments have a "thru" socket. There is no problem in using a single instrument of this type as it can simply be used at the end of the chain. However, with two or more instruments that lack a "thru" socket the daisy-chain method of connection is impossible, and the "star" system is the only way of connecting up the system successfully.

Another point to keep in mind is that MIDI equipment cannot be chained together indefinitely, and there must be a limit to the number of instruments that can be fitted into the system in this way. I have not come across anything in MIDI specifications that gives even the slightest hint as to the maximum number of instruments that can be wired in series, and possibly with correctly designed equipment it is so many as to make this factor of no practical importance. However, the "star" system avoids any "smearing" of signals through the system, and should ensure good reliability. It is probably the better system to use if your equipment supports it.

Being a fairly high speed asynchronous serial interface there is a definite limit to maximum length of connecting cable that can be used. The system is guaranteed to operate properly with connecting cables of up to 50 metres in length though, which should be more than adequate for even the largest system!

Fig.1 shows the basic set up for a typical MIDI system (the daisy-chain method of connection being used in this example). The controlling instrument need not be an instrument at all, and it could be a purpose built controller or a computer plus interface. The two instruments do not need to be keyboard types,

but could be drum machines, effects units, or any other MIDI equipment. In this example it has been assumed that the controller is a type which does not have its own keyboard. For some types of operation no keyboard is needed, but with most systems a keyboard is essential in order to get note information into the controller. The first instrument in the chain would then normally be a keyboard type (preferably one with a wide compass), and the MIDI output on this instrument is connected to the MIDI input of the controller. In a normal MIDI system only a single keyboard can be connected back to the controller. The MIDI "OUT" sockets on other instruments are therefore left unconnected.

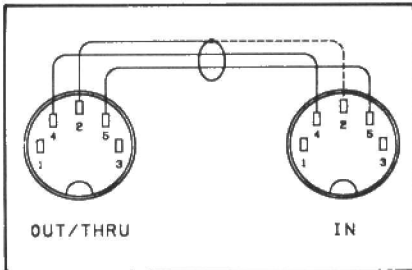


Fig.2. MIDI interconnections. A few items of equipment do not use 5 way DIN connectors

As far as the actual connecting cables are concerned, the arrangement of Fig.2 is all that is needed. The signal is carried by pins 4 and 5 of each socket, and it is basically just a matter of connecting these two pins on one socket to the corresponding pins on the other socket. The correct method of connection is for the two pin 4s to be connected together, and the two pin 5s to be linked (as in Fig.2), and not with cross coupling of these pins. Some ready-made 5 way DIN leads are intended for audio rather than MIDI use, and they have the wrong method of interconnection.

Pin 2 is used to earth the screen on the connecting cable. It is not essential to use a screened lead, but this avoids the radiation of strong radio frequency interference. The screen only needs to be connected at "OUT" or "THRU" sockets since pin 2 is left unconnected at "IN" sockets. It is often connected at "IN" plugs simply to provide a convenient method of terminating this lead of the cable. It is, of course, essential that the screen does not interconnect the chassis of the various items in the set up, which would make the opto-isolated inputs pointless.

The purpose of the opto-isolators is primarily to avoid problems with the high voltages that can exist between the chassis of various pieces of equipment within a system. These voltages are most likely to occur where two items of equipment do not have their chassis earthed to the mains earth lead, and they can result in damage to one or both pieces of equipment. Another advantage of opto-isolation is that it prevents noise

from a microprocessor based controller from being coupled into the instruments it is controlling. Last, but by no means least, it helps to avoid problems with "hum" loops, which are by no means a rarity in electronic music systems. Opto-isolation of the MIDI signal lines does not actually guarantee freedom from earth loops. There is still a risk of the audio and power cables introducing such loops. However, opto-isolation on the MIDI interconnection avoids having to worry about these when trying to sort out earth loop problems.

SWOPPING NOTES

The MIDI hardware merely ensures that information can be exchanged between items of MIDI equipment. This does not in itself make the equipment truly compatible, any more than two computers which have a RS232C interfaces are necessarily software compatible. A common set of instruction codes are needed to ensure that every MIDI controller will operate properly with the equipment it is controlling.

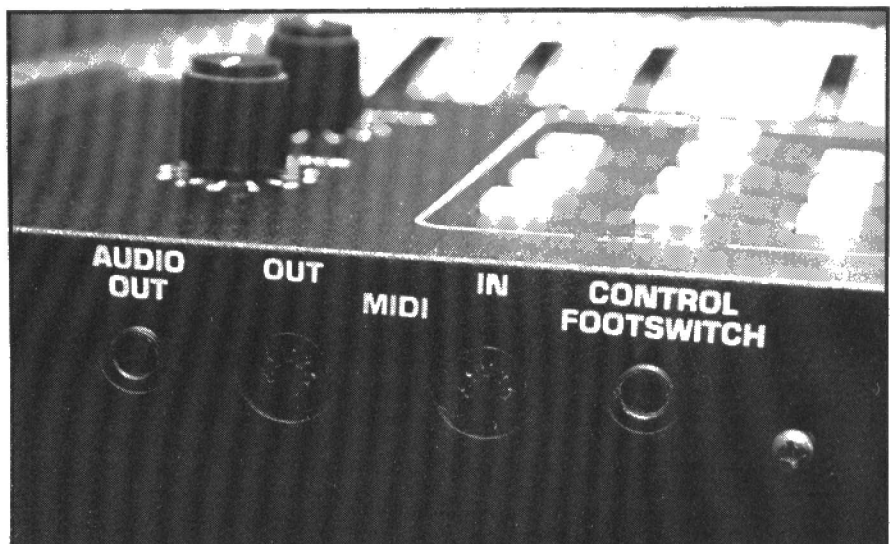
MIDI codes are generally in three byte groups, but more than one group might be needed for a complete action. For example, one group can select a note and switch it on, but a note duration cannot be specified. A second set of three bytes is therefore needed in order to switch the note off at the appropriate time. In the MIDI jargon, each group of three bytes is an "event". If a MIDI controller is said to have a storage capacity of (say) 2000 events, this does not mean that it can store 2000 notes. With two events required per note this actually represents a maximum storage capacity of 1000 notes. The capacity could be slightly less than this, since "events" other than note on/off information might have to be stored.

A note on/off sequence provides a good demonstration of the fundamental operation of the system. The first byte

of the sequence has to be considered as two 4 bit nibbles, with the most significant nibble carrying the "note on" instruction code. This is 1001 in binary, or 144 in decimal. The least significant nibble is the MIDI channel number which is from 0000 (0 decimal) to 1111 (15 decimal). There is room for confusion here in that MIDI channels are normally numbered from 1 to 16, and the value used to select a channel is actually one less than the channel number. The point of having a channeling system is that it enables information to be directed to just one instrument in the system, or even to just one voice of one instrument.

The next byte is the note value, but the most significant bit is always set to zero. This gives an impressive note range of 0 to 127, which is a compass of over 10 octaves as the values represent semitone intervals. A note value of 60 represents middle C incidentally. In terms of frequency this gives a range which extends from less than 10Hz to over 12kHz. This is wider than is ever likely to be needed in practice, but remember that this is the MIDI operating range. Not all MIDI equipped instruments can handle the full range—in fact most seem to cover somewhat less than the full ten and a bit octaves. If an instrument receives a note value it cannot produce, this is generally handled by it producing the right note in the nearest octave it can manage.

The final byte in the first three byte sequence is the velocity value, and this is again in the range of 0 to 127. A value of zero represents minimum velocity, through to 127 which corresponds to maximum velocity. Obviously this information is irrelevant to non touch-sensitive instruments, and these will simply ignore it. An instrument of this type will transmit the velocity byte, but it will only be a dummy byte to make up the three byte group (with either the



Rear panels bristling with CV and gate sockets are no longer the order of the day. This is the SCI Six Trak's rear panel (it lacks a "THRU" socket)

maximum value of 127 or a medium value of 64 normally being sent).

Switching off a note uses a similar sequence, but the most significant nibble of the first byte has the "note off" code value of 1000 in binary, or 128 in decimal. Apart from this the bytes are exactly the same as in the "note on" sequence. Incidentally, a velocity value of 0 will always result in a note being switched off. Some MIDI equipment seems to use the "note on" code in order to activate and switch off notes, with a velocity value of 0 being used in the groups of bytes that switch notes off.

It is not necessary for instruction code bytes to be transmitted every time. It is therefore quite valid to have something like a single "note on" instruction followed by several sets of note data. This can speed things up slightly, but most instruments seem to transmit an instruction byte with each set of data.

OTHER CODES

As described so far, the MIDI system does no more than could be achieved with the old gate/CV interfacing system, albeit in a more convenient way as far as making the actual interconnections is concerned. There is plenty of capacity for instructions other than simple note on/off information, and codes are available which permit the control of practically any piece of electronic music equipment, including such things as mixers and digital delay lines.

Some of these additional instructions have general application, but others are specific to a particular type of MIDI device and will be ignored by most equipment. The general format for instructions is always the same, with an instruction byte being sent first. These all have the most significant bit set to 1, whereas data bytes always have the most significant bit set to 0. There can be any number of data bytes per instruction, including none at all, and this simple method of coding helps to avoid confusion between data and instruction bytes. The table shown below gives a brief description of the eight possible MIDI header codes, and a full description of those not covered so far will also be given.

CODE NUMBER	FUNCTION
1000	Note Off
1001	Note On
1010	Polyphonic Key Pressure
1011	Controls And Modes
1100	Program Change
1101	Overall Pressure
1110	Pitch Bend
1111	System Messages

MIDI HEADER CODES

One of the most important of the additional MIDI codes is the pitch

bender instruction. This simply enables the pitch of an instrument to be taken between the normal semitones. Without this ability it is impossible for pitch modulation and "gliding" from one note to another to be controlled via a MIDI link. The four bit code for pitch bend is 1110 in binary (239 in decimal), and it is followed by two data bytes. These are combined to give a 14 bit value, but few instruments (if any) have 14 bit resolution. The usual system seems to be to have seven bit resolution with the second byte containing a dummy value. Seven bit resolution gives 128 steps between notes, which is quite adequate in practice. With this degree of resolution there is no apparent stepping in pitch, and smooth glide/modulation effects can be obtained. This assumes that the modulation is applied by stepping the pitch bend value one by one of course. The MIDI standard does not specify a relationship between values and amount of pitch bend, which unfortunately makes pitch bending a bit unpredictable.

PATCH CHANGE

An important code is the patch change type, or program change as it is sometimes called. This is used with instruments that have a number of pre-programmed voices to enable the instrument to be switched to the desired voice. The four bit binary header code is 1100, which is 192 in decimal, and this is followed by a single data byte. This gives some 128 selectable voices, but this is another case where MIDI can accommodate a wider range than many instruments can actually justify.

Two types of instruction that are not likely to be of great interest to most users are polyphonic key pressure (1010) and channel pressure (1101). Few instruments incorporate overall after touch, and even fewer have after touch for individual keys. Possibly these will be implemented to a greater extent in the future as instruments become more sophisticated. The polyphonic pressure instruction is followed by two bytes which give the note and pressure values (127 representing maximum pressure). With the channel pressure command only one data byte is required as no key number is given.

The control change or parameter change code is perhaps not one which is used very often, but it gives the MIDI system tremendous power and versatility. The binary header code is 1011 in binary (176 decimal), and this is followed by two bytes. The first carries the identification number of the control which is being altered, and the second byte specifies the new value. The way in which this system operates is less than entirely straightforward. Numbers from 0 to 63 are used for 32 controls of the continuously variable type, which normally means something that would be manu-

ally controlled via a potentiometer. The numbers are used in pairs, with one followed by the most significant data byte, and the other followed by the least significant data byte. The following table should help to clarify the way in which this is organised.

CONTROL NUMBER	CONTROL VALUE	DATA BYTE
0	0	MSB
0	32	LSB
1	1	MSB
1	33	LSB
2	2	MSB
3	34	LSB
etc.	etc.	etc.
31	31	MSB
31	63	LSB

CONTROL CHANGE BYTES

This gives 14 bit resolution, but two sets of three bytes must be sent in order to fully reset a control value. Much equipment does not actually support 14 bit resolution. This greatly simplifies matters as 7 bit resolution is then used, with no LSBs being transmitted, and control values from 32 to 63 being left unused.

Control values from 64 to 95 are used for switch type controls. The data byte is either 0 for off or 127 for on, and these are the only two valid data values for these controls. Control values 96 to 121 are not defined by the MIDI standard. Values from 122 to 127 are used for channel mode messages and are really totally different to control values and settings. A value of 122 is followed by a data value of 0 to disconnect an instrument's keyboard so that it can only be played via the MIDI interface. The same instruction with a data value of 127 reconnects the keyboard. A control value of 123 followed by a data value of 0 switches off all notes.

Control values from 124 to 127 are also "notes off" commands, but they serve additional functions. They select the MIDI mode, as detailed below:-

Control Value	Data Value	Effect
124	0	Omni Mode Off
125	0	Omni Mode On
126	No. of Channels	Mono Mode On
127	0	Poly Mode On

MIDI MODE CODES

Control 1 is the modulation control, but the MIDI standard does specifically assign any other controls to definite functions. This gives plenty of flexibility, but can compromise compatibility between various items of gear.

IN THE MODE

Mode changing commands are all very well, but just what are the available MIDI modes? They were originally given numbers, but they now have names, although the names seem to have changed recently. Anyway, whatever their names, there are still four of them, as detailed here.

MODE 1, OMNI ON/POLY (OMNI MODE)

This is the start-up mode, the simplest mode, and is one that all MIDI instruments have. The important point about this mode is that it ignores any channel numbers, and the instrument will respond to note information on any channel. Just which voice received notes are played on depends entirely on the internal organization of the instrument. In general, notes received on the MIDI interface will be assigned in just the same way as notes received by way of the keyboard. In this mode the instrument would normally be used with all voices set to give the same sound so that the matter of which note is played on which channel is of no importance.

MODE 2, OMNI ON/MONO

In mode 1 an instrument will play polyphonically provided it has more than one channel. This mode is basically the same as mode 1, but the instrument is effectively down-graded to a mono-phonetic type. With only one voice in operation this obviously gives a problem if polyphonic information is received. The MIDI standard allows three methods of handling this eventuality. The instrument can either respond to lowest, highest, or (more usually) the last note received, with some instruments allowing the user to select the desired method.

MODE 3, OMNI OFF/POLY (POLY MODE)

In this mode the instrument is assigned to a single MIDI channel, but in the case of a polyphonic instrument it still operates polyphonically. This is similar to mode 1, but it is more versatile with the instrument only responding to information on one channel. The instrument has to be assigned to the appropriate channel of course, and it is the base channel that is used (see below).

MODE 4, OMNI OFF/MONO (MONO MODE)

Although the "Mono" in the title of this mode makes it sound rather limited, this is actually the most powerful mode of all. It only applies to a polyphonic multi-voice instrument, and it gives each voice its own channel. The user can set the base channel, which is simply the lowest channel used by the instrument. Thus, with an eight channel instrument

set to a base channel of 5, its eight voices are on channels 5 to 12.

The power of the mono mode should be readily apparent. With a sixteen channel synthesizer which supports this mode you have what is virtually a programmable orchestra! It can be used to good effect in conjunction with mode 3. A typical set up of this type would have (say) an eight or sixteen note polyphonic instrument such as an electronic piano on channel 1, with a synthesizer providing different voices on channels 2 to 16. If you have sufficient equipment you could actually have separate polyphonic instruments on each of the sixteen channels using mode 3, but in practice this is beyond the means of all but the most well heeled of musicians!

BEAT THE SYSTEM

There is a category of MIDI instruction that has not been considered so far, and this is the "system message" type. These differ from the data messages in that they do not contain a channel number, and are directed to the whole system. These serve more than one purpose, but are primarily used for synchronization purposes. The general idea here is to permit a synthesizer and a drum machine to play in unison without a continuous stream of voice messages being passed from one to another. The two instruments have their own sequencers which are programmed separately, and then the timing codes are used to keep them in unison.

System messages have 1111 (binary) or 240 (decimal) as the most significant nibble of the instruction byte. With the least significant nibble no longer being needed to specify a channel number it is available to identify the type of system message being sent. The table given below gives a brief description of the codes that have been assigned definite functions (the rest are all unassigned codes).

CODE-FUNCTION	DATA BYTES
0 Exclusive	Manufacturers identification, data (any number of bytes), end of instruction command (code 7).
2 Position Pointer	Two bytes (MSB, LSB)
3 Song Select	Song number
6 Tune Request	None
7 Exclusive End	None
8 Clock Signal	None
10 Start	None
11 Continue	None
12 Stop	None
14 Active Sensing	None
15 System Reset	None

ASSIGNED FUNCTION CODES

The system exclusive mode enables the exchange of non-standard MIDI information, and this enables manufacturers to design a product range that will operate together in a sophisticated manner that would otherwise be beyond the capabilities of the MIDI system. On the other hand, it does mean that the facilities of some MIDI equipment can only be exploited if other items of equipment in the system are from the same manufacturer. This slightly goes against the original concept of the MIDI system. A manufacturers identification code follows this instruction, which is essential if malfunctions are to be avoided. Equipment from the wrong manufacturer must ignore any system exclusive data as it would interpret it incorrectly. There is no limit to the amount of data that can follow this instruction, and in practice there is often a considerable amount of data. For example, the system exclusive command is sometimes used for dumping a full set of patches, and this can mean a whole set of parameters for over one hundred stored voices. The system message instruction with 7 as the least significant nibble indicates the end of the data.

Codes from 8 to 15 are for "real-time" system messages, and these are largely self explanatory. None require data bytes as they are essentially just on/off style commands. Timing clocks are sent at the rate of 24 per crochet, and for optimum accuracy they can be sent at any time. This apparently means that they can be sent in the middle of the other messages! There may seem to be no point in having messages such as "start", and "stop", but some equipment sends a continuous stream of timing messages. These must be ignored until a "start" or "continue" instruction is received, and after a "stop" command is received. The active sensing instruction is sent at 300ms (or less) intervals by the controller to indicate that it is still present and in command of the system. This is not something that is implemented in every system, and consequently the controlled equipment should only respond to this code once the initial active sensing message has been received. The general idea is that the controlled equipment can automatically switch back to its normal mode of operation when an active sensing message has not been received for more than 300ms.

Codes 1 to 6 are system common messages, and two of these are closely allied to the real-time messages. These are codes 2 and 3 which enable sequencing to jump to a certain point in the desired sequence. Code 6 is used to initiate automatic tuning on an analogue synthesizer.

IN CONTROL

This quick once over of the MIDI system should demonstrate the power

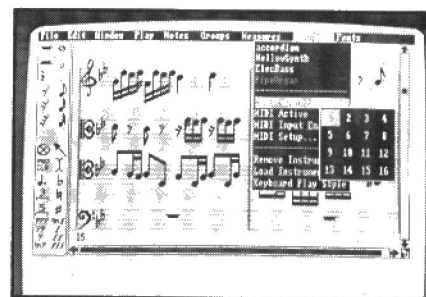
and flexibility of the system. If you simply want one instrument to play along with another in order to give a "thicker" sound, then simply connecting "MIDI OUT" on the first instrument to "MIDI IN" on the second will do the job. If you want to computer control a bank of synthesizers, this is also within the capabilities of the system. The future of MIDI certainly seems to lie with computer control, which seems to be gaining in popularity all the time.

The most popular method of control is probably the pseudo tape recorder type. With this the software provides the user with normal tape recorder command such as "play" and "record", and with many systems multi-tracking is possible. The versatility of such a set up goes well beyond that of a "real" multi-track tape recorder in that once tracks have been recorded there is no difficulty in editing them. This editing can be in the form of stretching or shortening notes, pitch changes, voice, changes, or virtually anything provided the system is refined enough to support it.

The other approach is step-time sequencing where the music is programmed from the computer and not played manually at all. This again allows comprehensive editing of pieces. For educational and professional use the notation programs are possibly the most useful. These use the computer's

graphics to give representations of staves onto which notes are placed, together with a time signature, etc. Notation programs normally permit comprehensive editing, and are sometimes called "note processors" as they do for music what word processors have done for the written word. The finished music is then played via the MIDI interface, and a piece can, of course, be played at any stage during its development. A more than slightly useful feature of many notation programs is their ability to print out music on a dot matrix printer.

In general there is a trend towards user-friendly software that requires a minimal knowledge of the MIDI system on the part of the user. A good background knowledge of the subject is still useful though, as it helps in the avoidance of problems, and in solving any that do occur. An important point for all MIDI users to keep in mind is that the MIDI specification sets down rules for manufacturers to keep within, but few instruments (possibly none) have a full implementation of the standard. Some quite expensive instruments lack mode 4 for instance, or it might be found that pitch bending sent to one channel actually affects all the channels of an instrument. There are still relatively few instruments that both transmit and respond to touch sensitivity information. Anyone intending to make extensive use



Deluxe Music Construction Set can use the Amiga's internal sound generator to good effect, but it also has good MIDI capabilities

of MIDI interfacing should thoroughly read the manuals of their instruments (or any that they are contemplating buying) to make sure that the instruments concerned actually support the required MIDI functions. The fact that a facility is available under manual control does not necessarily mean that it is available via the MIDI interface.

For those who wish to develop their own hardware and/or software the MIDI system offers plenty of scope. Do-it-yourself multichannel synthesizers are perhaps a thing of the past, but there are plenty of useful MIDI projects that the electronics enthusiast can construct. Some will be appearing in future issues of Practical Electronics. **PL**

Astronomy Now

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SPEECH PROCESSOR

BY THE PROF

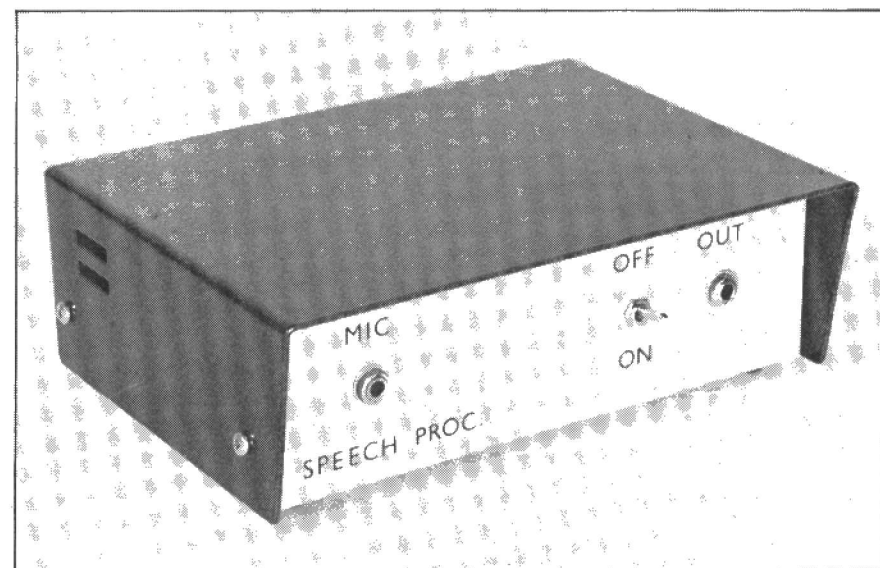
Restricted speech aids communication

Spoken voice links are one of the least efficient ways of communicating information electrically, but the most natural to us humans. The classic compromise is to clip or compress the speech signal into smaller bandwidths. Here we look at several ways of doing it.

THERE must be numerous non-voice forms of electronic communications, ranging from morse code through to the latest in digital systems, and many of these are more effective than voice communications. Despite this, I would guess that the majority of electronic information exchange takes place via voice links. This is presumably due to reasons of convenience rather than performance considerations. Non-voice systems generally give better reliability and require a narrower bandwidth for a given rate of information exchange. Consider an ordinary 1200 baud full duplex modem. This can handle around 120 characters per second (which is about 20 words per second) with simultaneous communications in both directions, which is obviously vastly more than could be handled with a speech link.

There are various ways of obtaining improved performance, and the subject of voice compression (speeding up speech without producing frequency shifts) was covered in a previous 'Experimental Electronics' article. Another way in which performance can be improved is to increase the so-called 'talk power' of the signal. This really means making the signal as effective and powerful as possible within given peak amplitude limits. Most voice links have some form of processing to boost performance, even if it is only in the form of some simple filtering. Bass frequencies do not aid intelligibility to a significant degree, and can even hinder it to a limited extent. Removing bass frequencies enables the remaining signal to be boosted slightly without giving any increase in the peak amplitude, and this makes it slightly more effective. Another benefit is that reduced bandwidth can be used at the receiving equipment, making it slightly less vulnerable to problems with noise and general interference.

Filtering at the other end of the spectrum is also used routinely in voice communications systems. Some high frequency components do significantly aid intelligibility, but using lowpass filtering with a cutoff frequency at about 3kHz or a little less does not greatly hinder the clarity of the signal, and the removal of these frequencies again enables the remaining signal to be boosted without the signal going beyond its original peak levels. The reduced bandwidth that can



be used at the receiving equipment can vastly reduce noise and interference problems.

COMPRESSION

Another common form of voice-signal processing is to use compression, and in this case I mean compression in the sense of a circuit that reduces the dynamic range of the processed signal. The idea here is to ensure that the peak level of the signal is always maintained at something approaching the maximum acceptable level, even though, for one reason or another, the input level to the microphone might vary considerably.

There is nothing particularly complex about a compressor circuit, and there are special VOGAD (voice operated gain adjusting device) integrated circuits for this application, such as the Plessey SL6270C. The general arrangement used in these circuits is shown in the block diagram of Fig.1. The low level microphone signal is first boosted by a preamplifier, and then it is fed to a

voltage controlled attenuator (v.c.a.). From here it is fed to the output by way of a voltage amplifier. Some of the output signal is rectified and then smoothed by a circuit which sets suitable attack and decay times. The resultant d.c. signal is used as the control voltage for the v.c.a., and the unit is arranged in such a way that increased control voltage gives increased attenuation.

For the present application the unit should ideally be designed so that there is zero output voltage from the time constant circuit until virtually the maximum acceptable output level has been reached. A very small change in control voltage should give a very large variation in the attenuation through the v.c.a. The point of this is to give a form of limiting action, where the input signal undergoes no significant compression until it reaches a certain level, and taking the input above that level then gives no significant rise in the output amplitude. This maintains the output signal accurately at the required level,

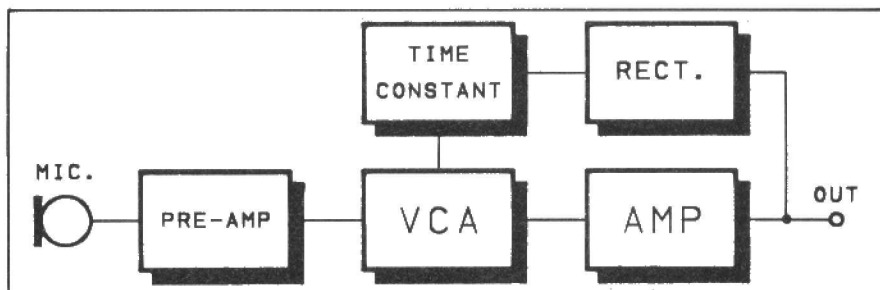


Fig.1. Block diagram for a typical VOGAD system

provided a strong enough input signal is supplied to the system.

For good results it is generally necessary to adopt a fast attack time so that the circuit responds rapidly to high level signals, so that the gain of the circuit is turned back almost instantly and overloading is avoided. Ideally the system would have a fairly fast decay time as well so that it responded rapidly to falls in signal level and maintained the output level even with rapid variations in the input level. In practice it is usually necessary to resort to a relatively long decay time which is often as much as a few seconds. A short decay time can easily introduce problems with distortion and even severe instability. It is a matter of choosing a compromise between decay time and flatness of response that is well suited to a particular application. Some systems use two compressors in series; the first with a fairly fast decay time but a not particularly flat compression characteristic, followed by the second with a flat compression response but a much longer decay time. Such a set up can be very effective.

FUZZ BOX?

Most speech processors go beyond filtering and compression techniques, and actually try to alter the signal in a way that boosts its apparent volume without altering the peak level. This may sound a little unlikely, but it is actually quite possible, and the improvement that can be made is probably more than you would think. In fact an apparent boost of up to about 6dB can be obtained, which is an effective doubling

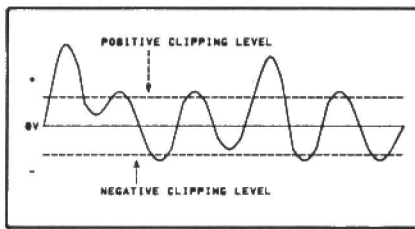


Fig.2. Using clipping to obtain a higher average amplitude for a given peak level

of amplitude, or if applied to (say) an s.s.b. radio transmitter it is equivalent to a fourfold increase in output power. It is only fair to point out that some items of equipment which could benefit from speech processing already have built-in processing circuits, and any external processing is then destined to be ineffective. More importantly, some equipment is designed on the basis of the input signal being an ordinary voice signal, and a processed signal could cause overloading. Provided it is only used where appropriate though, speech processing can provide more effective communications links. It can also be applied to non-communications applications, such as public address equipment where there is often a high background noise level to contend with.

The basic system used in speech processing is simple clipping. Fig.2 helps to explain the way in which the processing operates. A typical speech waveform is, as depicted in Fig.2, a non-symmetrical and rather random looking type. The main point to note here is that the average level is quite low in comparison to the peak level. Whereas the peak to average amplitude ratio of most waveforms (square, triangular,

etc.) is around two to one, for a speech signal it is more likely double this figure. Clipping the signal at the levels shown in Fig.2 would obviously give a much lower peak to average amplitude ratio, and would give an apparently louder signal for a given peak amplitude. Unfortunately, clipping introduces severe distortion, and it would be easy to design a speech processor that worked better as a guitarists' fuzz box than as a speech processor. Obviously there is no point in making the signal more powerful but less easily understood!

I doubt if a truly distortionless speech processing system exists, but there are ways of using clipping without obtaining the 50% or so of distortion that normally accompanies it. In fact distortion levels of under 1% can be obtained on a heavily clipped signal with suitable pre and post processing. The most sophisticated forms of speech processor are the radio frequency (r.f.) types. These will not be considered in this article, but it is a subject to which we will probably return in a later article. Quite good results can be obtained using speech processors that operate purely at audio frequencies, and the most simple type operates with a system of input and output filtering.

In order to understand the way in which this operates it is first necessary to understand the nature of the distortion products that are produced by the clipping process. There are two types of distortion products, those produced by harmonic distortion, and those generated by intermodulation distortion. Harmonic distortion simply generates multiples of the input

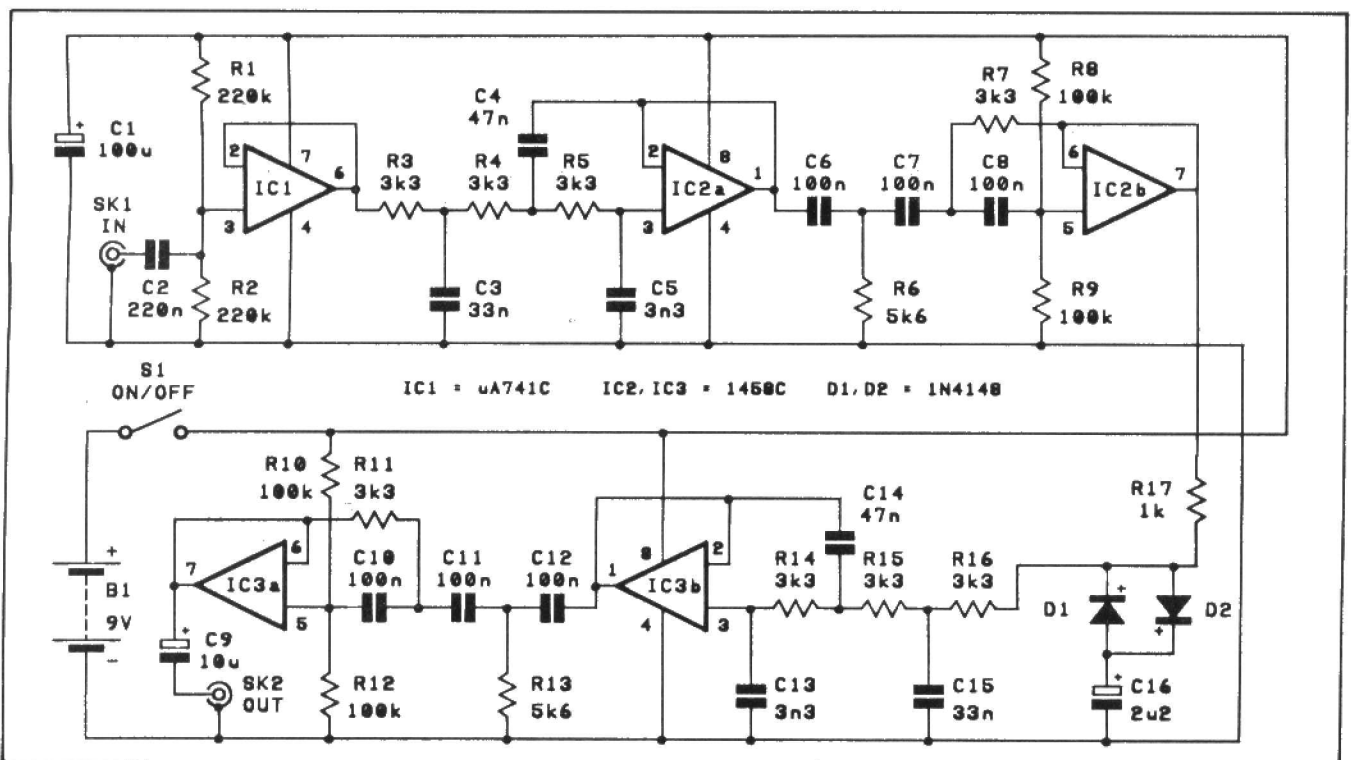


Fig.3. The circuit diagram for a fairly basic but effective speech processor

frequency or frequencies. For example, a 1kHz input signal would generate distortion products at 2kHz, 3kHz, 4kHz, etc. due to harmonic distortion.

Intermodulation distortion is more complex, and requires at least two input frequencies. It results in the generation of sum and difference frequencies. For instance, with input signals at 100Hz (0.1kHz) and 1kHz (1000Hz) it would result in distortion products at 1.1kHz (1kHz plus 0.1kHz) and 900Hz (1000Hz minus 100Hz). In a practical input signal there is generally a number of input frequencies, and intermodulation distortion consequently produces a vast range of output frequencies. In the present context the most important point to note is that harmonic distortion only produces frequencies that are higher than the input frequency that produced them, whereas with intermodulation distortion the distortion products can be higher, lower, or even at the same frequency as one of the input frequencies that produced them.

By restricting the bandwidth of the input signal to the minimum required for intelligible speech, the number of frequencies on the input signal is reduced, and this helps to minimise the number of distortion products that are generated. In particular, attenuating the low frequencies prevents these from generating strong harmonics at middle audio frequencies, which would give very obvious distortion on the output signal.

The input filtering certainly helps substantially in the quest for a good quality output signal, but it is mainly the output filtering that cleans up the signal to give an output of acceptable quality. In particular, both intermodulation and harmonic distortion generate strong high frequency components that can be severely attenuated by lowpass filtering at the output. In its most basic form then, a speech processor consists of a high pass filter ahead of the clipping circuit, and a lowpass filter at the output.

PROCESSOR CIRCUIT

Fig.3 shows the circuit diagram for a fairly basic but quite effective speech processor. IC1 merely acts as an input buffer stage which provides an input impedance of over 100k and a low output impedance to drive the next stage of the unit. This is a third order (18dB per octave) lowpass filter having a cutoff frequency at about 3kHz, and it is followed by a third order highpass filter having a cutoff frequency of about 300Hz. The clipping circuit is a standard twin silicon diode type which clips the signal at about plus and minus 0.6 volts. This is followed by a highpass-lowpass filter arrangement which is identical to the one used ahead of the clipping circuit.

Note that the circuit does not incorporate a microphone preamplifier, and it requires an input signal of a few volts peak to peak. The output signal does show obvious signs of distortion on heavily clipped parts of the signal, but the quality of the output signal is acceptable provided the degree of clipping is kept within reason, and the unit certainly provides an increase in 'talk power'. It can actually be simplified somewhat by omitting the input lowpass filter and the output highpass stage, but this does seem to provide a small but noticeable reduction in the quality of the output signal.

SPLITTING PAIRS

Significant amounts of distortion are present on the output signal of a processor of the type just described as it covers a frequency range of more than one octave. This makes it inevitable that there are low input frequencies which produce strong harmonics within the passband of the system. The passband is also wide enough to leave the system open to production of strong intermodulation components within the passband.

bandpass filter. The input bandpass filter would also ensure the absence of any combination of input frequencies that could generate strong intermodulation distortion products within the passband of that channel.

This system is not perfect in that the filters would severely attenuate the distortion products, but would not totally eliminate them. It is therefore not truly distortionless, although a practical design could be designed to give distortion levels that would be totally insignificant. The system is impractical due to its complexity. For really good results it would probably be necessary to split the input signal into about seven or eight bands, and this would necessitate the use of fourteen or sixteen high quality bandpass filters. This would certainly make the unit more complex than a good r.f. speech processor, and could well render it more expensive as well. It would be an interesting idea to try out, but it is not one I felt to be worth pursuing in this form.

Instead I tried out the simplified arrangement of Fig.5. This splits the input signal into just a pair of bands, with one covering from around 250Hz

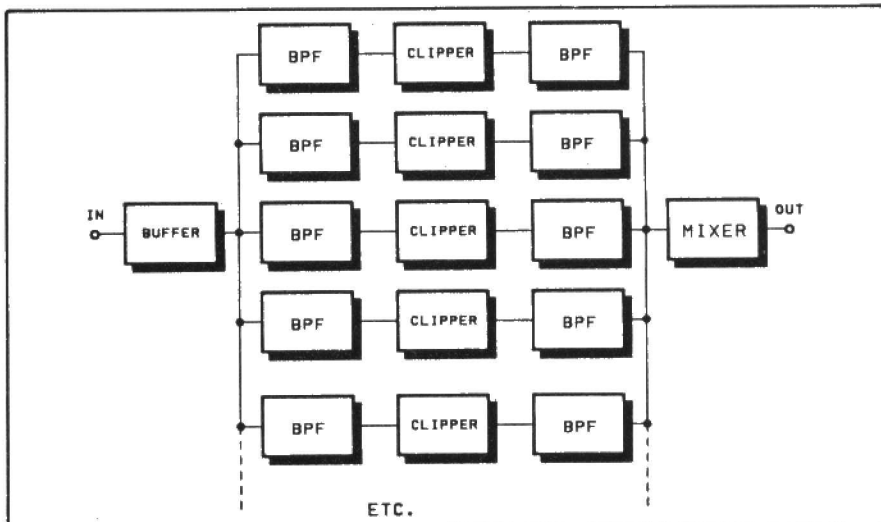


Fig.4. An arrangement which gives distortionless speech processing

In theory it is possible to virtually eliminate both the harmonic and intermodulation distortion products, and this can be achieved using a set up of the type outlined in the block diagram of Fig.4. This is in essence much the same as the system described previously, but instead of using a single filter-clipper-filter arrangement, a number of these circuits are used. The idea is to have the audio band broken up into a number of narrow bands, with each one having its own clipping circuit. By splitting the signal, processing each band separately, and then mixing all the processed signals together again, the system can have a reasonably flat overall frequency response. With each band restricted to (say) half an octave, any harmonics produced by the clipping circuit will be outside the passband of the following

to 600Hz, and the other covering a 900Hz to 2800Hz range. This actually gives a pronounced dip in the middle of the audio band, but apparently most voices have little content between about 600Hz and 1.2kHz, and even wider gap would give perfectly usable results. On feeding a number of different voices through the system the theory seemed to be borne out in practice, and the audio output quality seemed to be perfectly acceptable as far as the frequency response was concerned. Of course, by splitting the input signal into just two bands, even with a gap left in the middle of the range, each band must cover more than one octave rather than less. This leaves the system open to distortion on the output, but much less so than if no splitting was used at all, and the complexity of the circuit need be little

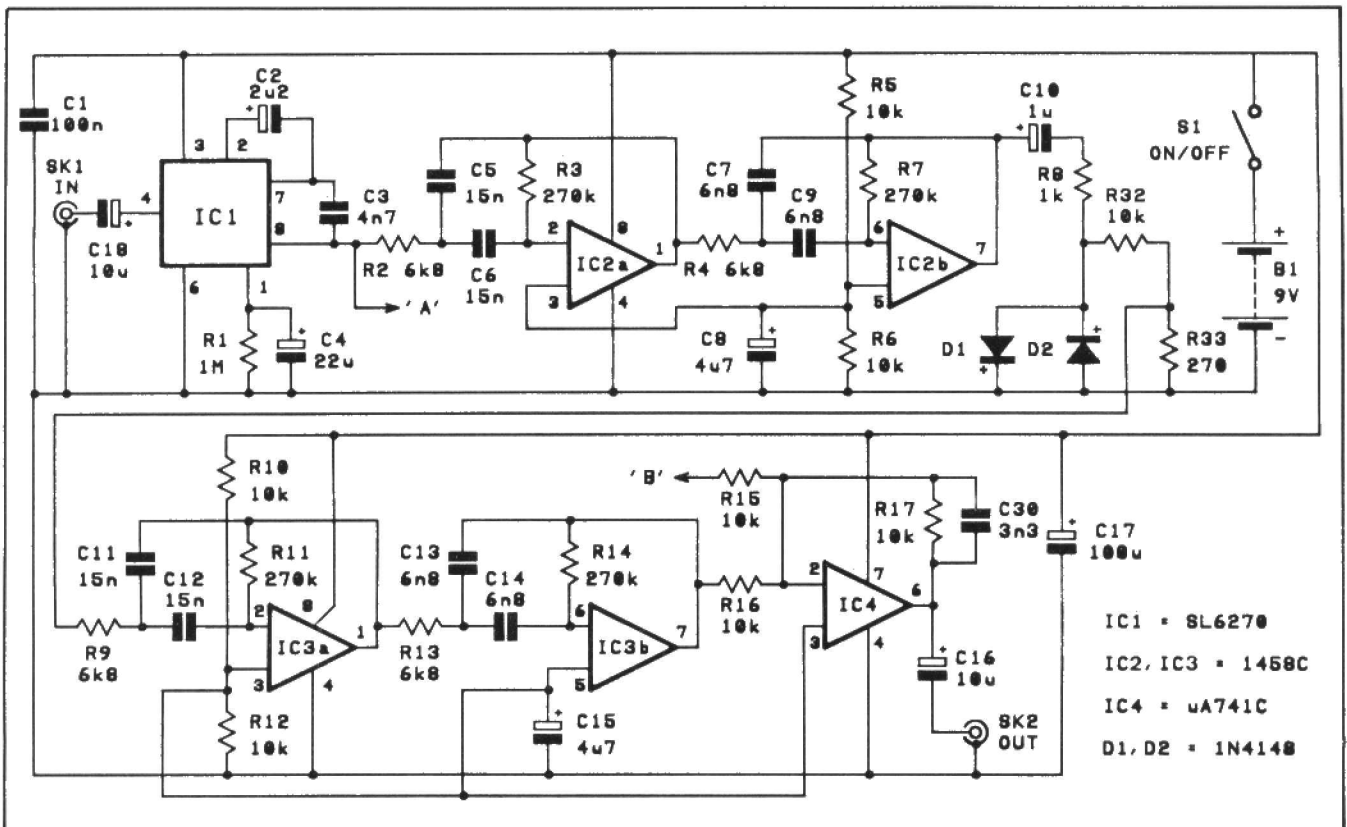


Fig. 6. The main circuit of the twin channel speech processor

more than that of a basic unit of the type described earlier.

Note the inclusion of a VOGAD circuit at the input of the unit. This is not just to ensure that the input signal is brought up to a suitable level to drive the unit properly, but it also prevents the optimum clipping level from being greatly exceeded. This is important with an audio speech processor where grossly excessive clipping could produce large amounts of distortion regardless of the filtering.

THE CIRCUIT

The main circuit for the two channel speech processor unit appears in Fig. 6, with the circuit for the second channel being shown separately in Fig. 7.

Taking the main circuit first, IC1 is an SL6270 VOGAD integrated circuit, and this is designed for use with a low impedance (about 600 ohms) communications microphone. It is shown here as having an ordinary unbalanced input, but for balanced input

operation it is merely necessary to use pin 5 of IC1 as the second input. A 22k resistor can be connected from pin 5 to earth if the circuit shows signs of instability, but no problems of this type were experienced with the prototype equipment. R1 and C4 are part of the smoothing circuit, and with the specified values the decay rate is reasonably fast at well over 20dB per second. C3 provides some initial filtering by rolling-off the frequency response of the circuit at frequencies above about 3.5kHz.

The bandpass filters must provide a high roll-off rate outside the passband, but they must give a reasonably flat response within the passband. A high Q filter gives the required sharpness of response, but also tends to give an excessively narrow and peaky response. A low Q filter gives a sufficiently broad passband, but an inadequate attenuation rate in the stop-band. There seems to be no compromise Q value which gives good results, and so a dual bandpass filter circuit was finally adopted. This has two conventional operational amplifier

bandpass filters connected in series, but having slightly different centre frequencies. This gives a sufficiently broad passband together with a fairly high attenuation rate.

The clipping circuit is a conventional twin silicon diode type, and it is followed by another double tuned bandpass filter which is identical to the input filter. IC4 is operated as a standard summing mode mixer circuit which combines the outputs of the two channels.

As should be apparent from Fig. 7, the circuit of the second channel is much the same as that of the first channel. Obviously the VOGAD and output mixer stages are common to both channels, and the other difference is that in Fig. 7 the filter component values have been changed to accommodate the higher frequencies at which this circuit must operate.

CONSTRUCTION

Results using this circuit were sufficiently encouraging for the printed circuit board design of Fig. 8 to be provided for those who would like to try out the unit for themselves. Construction of the unit is extremely straightforward, and should give no real problems provided the miniature capacitors specified in the components list are used (7.5mm pitch components in the case of the polyester layer types). None of the integrated circuits are MOS types, but as the SL6270C is not one of the cheapest types I would strongly urge the use of a socket for this device even if the others are fitted direct.

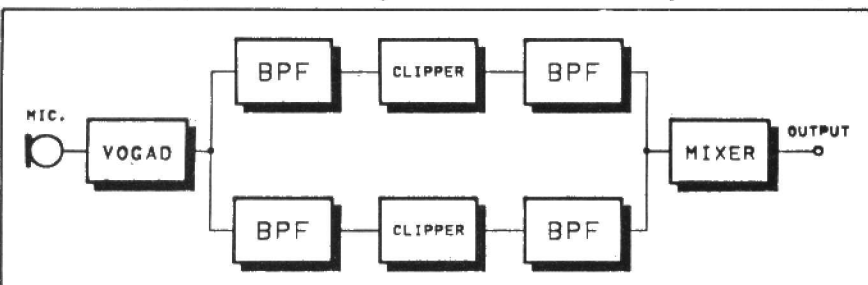


Fig. 5. A simplified system using just two bands with separate clipping stages

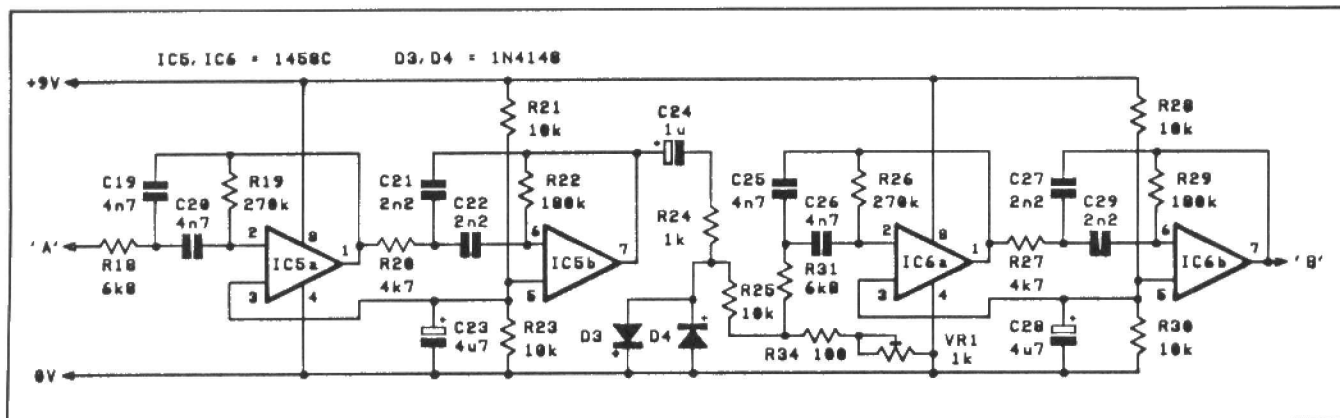
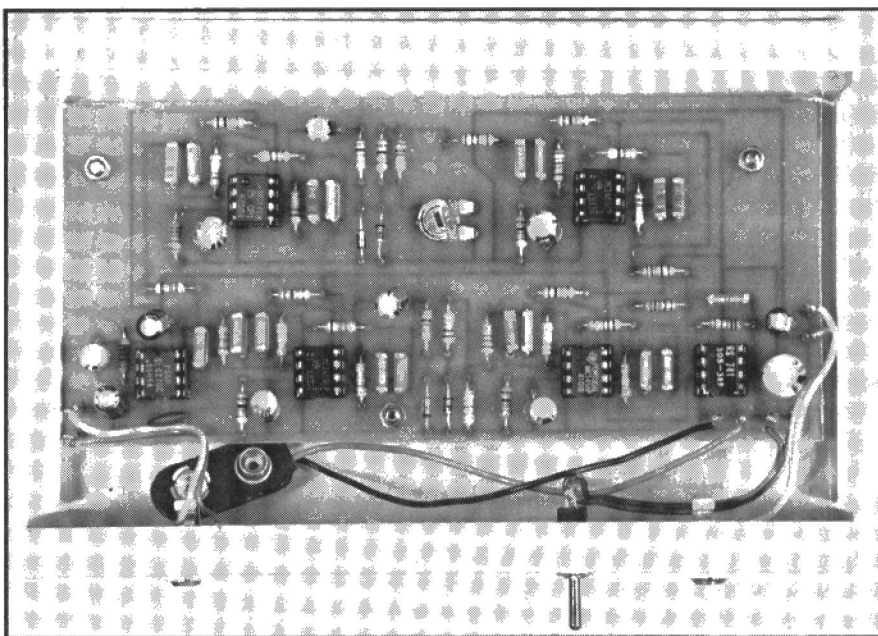


Fig.7. The circuit diagram for the second channel of the speech processor

The unit can be built into some more major item of equipment, or, like the prototype, it can be constructed as a self-contained add-on unit. A metal instrument case is ideal as the housing, and one with outside dimensions of approximately 150 by 100 by 50 millimetres represents about the minimum size that will accommodate all the components properly. The output signal is a few volts peak to peak in amplitude, and in some cases it should be possible to directly use this high level signal. Where possible, it is definitely better to do so, but in some cases the unit will have to drive a microphone input, and an attenuator will then be needed at the output in order to reduce the output level to one that is comparable to the normal output level of the microphone. This gives something less than optimum noise performance, but is generally the easiest way of doing things.

The only adjustment which must be made to the finished unit is to set VR1 to give a level of gain from the higher band that matches that from the lower band. With the aid of suitable test gear there is no difficulty here, and in the



absence of suitable test equipment VR1 can simply be set for what is deemed to be the best subjective audio output quality. Alternatively, R34 can be raised to 270 ohms in value and CR1 can be

replaced with a shorting link. If this is done it is advisable to use 1% resistors in the filter and mixer stages and 5% filter capacitors in order to minimise any mismatch in the filter gains.

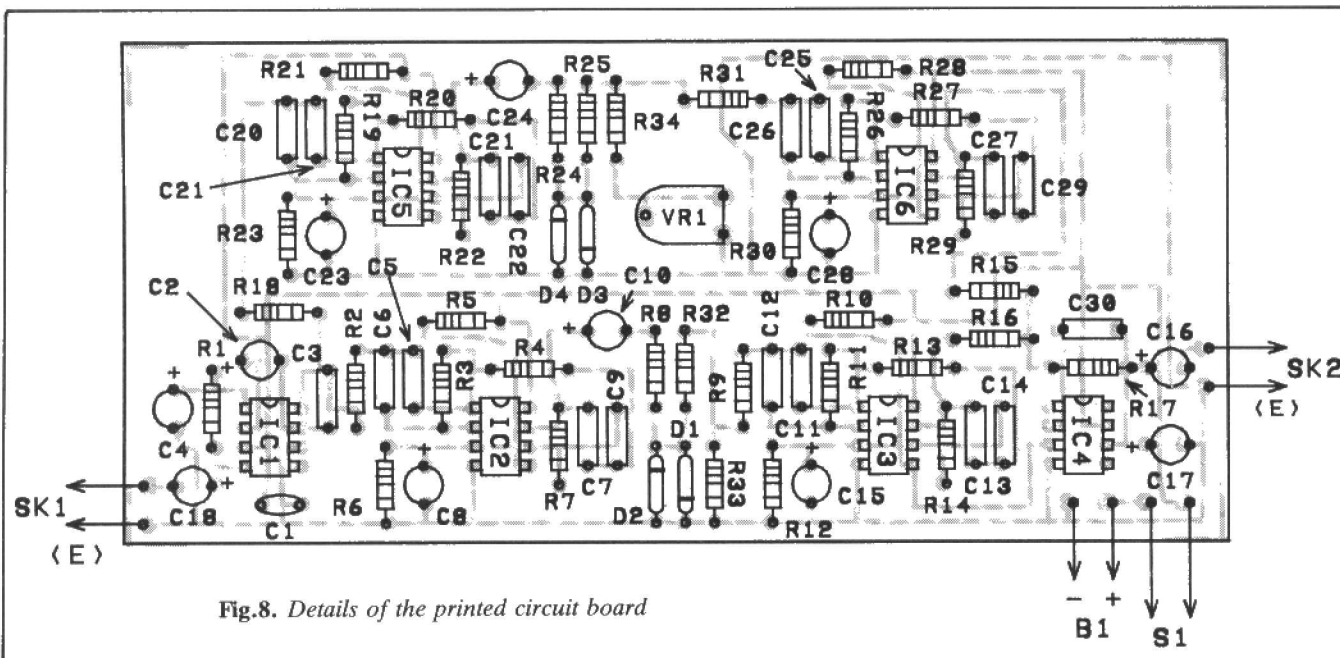


Fig.8. Details of the printed circuit board

COMPONENTS

RESISTORS

R1	1M
R2,R4,R9,R13,R18,R31	6k8 (6 off)
R3,R7,R11,R14,R19,R26	270k (6 off)
R5,R6,R10,R12,R15,R16,R17,R21,R23,R25,R28,R30,R32	10k (13 off)
R8,R24	1k (2 off)
R20,R27	4k7 (2 off)
R22,R29	180k (2 off)
R33	270
R34	100
All resistors 0.25w 5% carbon	

POTENTIOMETER

VR1	1k sub-min hor preset
-----	-----------------------

CAPACITORS

C1	100n ceramic
C2	2μ2 63Vradial elect
C3,C19,C20,C25,C26	4n7 polyester layer (5 off)
C4	22μ16Vradial elect
C5,C6,C11,C12	15n polyester layer (4 off)

C7,C9,C13,C14	6n8 polyester layer (4 off)
C8,C15,C23,C28	4μ7 63Vradial elect (4 off)
C10,C24	1μ 63Vradial elect (2 off)
C16,C18	10μ 25Vradial elect (2 off)
C17	100μ 10Vradial elect
C21,C22,C27,C29	2n2 polyester layer (4 off)
C30	3n3 polyester layer

SEMICONDUCTORS

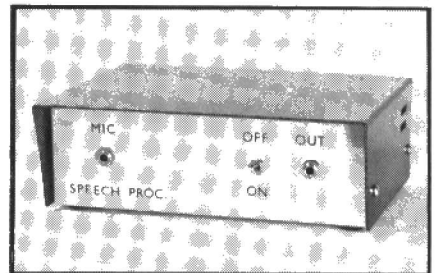
IC1	SL6270C
IC2,IC3,IC5,IC6	1458C (4 off)
IC4	μA741C
D1,D2,D3,D4	1N4148 (4 off)

MISCELLANEOUS

S1	SPST sub-min toggle
B1	9 volt (PP3 etc)
SK1,SK2	3.5mm jack socket (2 off)

Case about 150 x 100 x 50mm printed circuit board 8 pin DIL IC holder (6 off), battery connector wire, solder, fixings, etc.

good, the unit does leave room for improvement and it could be developed further. The output from the higher frequency channel seems to be 'cleaner' than that from the lower channel. One possible improvement would be to add a high slope (about 24dB per octave) lowpass filter between IC3b and R16, to increase the attenuation of distortion products on this signal. What might be more effective would be to process the lower frequency channel as two separate channels. The unit might then give a level of performance to match r.f. speech processors, but at a somewhat lower cost. However, using modern low cost mechanical filters it is possible to produce a high quality r.f. speech clipper at moderate cost, as we shall see in a later article. **PE**



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IMPROVEMENTS

Results with the unit seem to be quite good, with acceptably low levels of distortion on heavily clipped signals. Although I was originally a little

skeptical about the effect of the far from flat frequency response on the audio quality, this does not really seem to have any great detrimental effect, and does not hinder intelligibility. Although quite

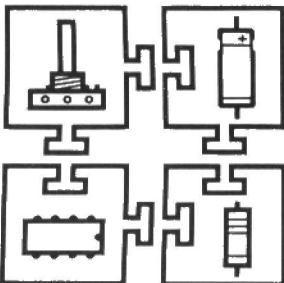
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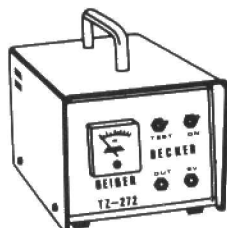


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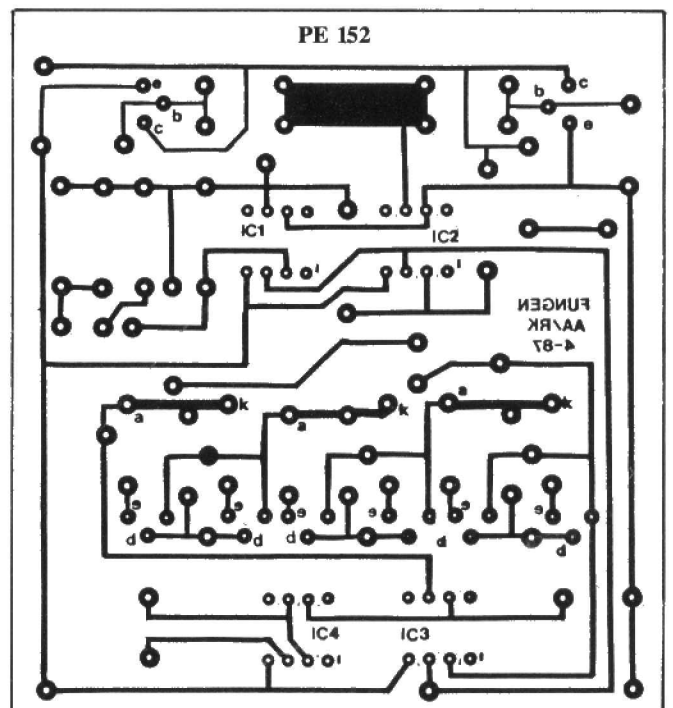
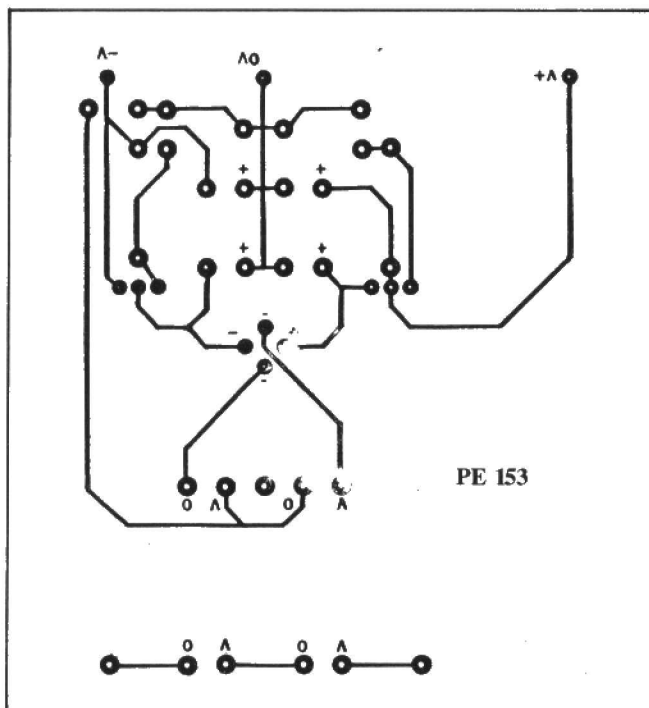
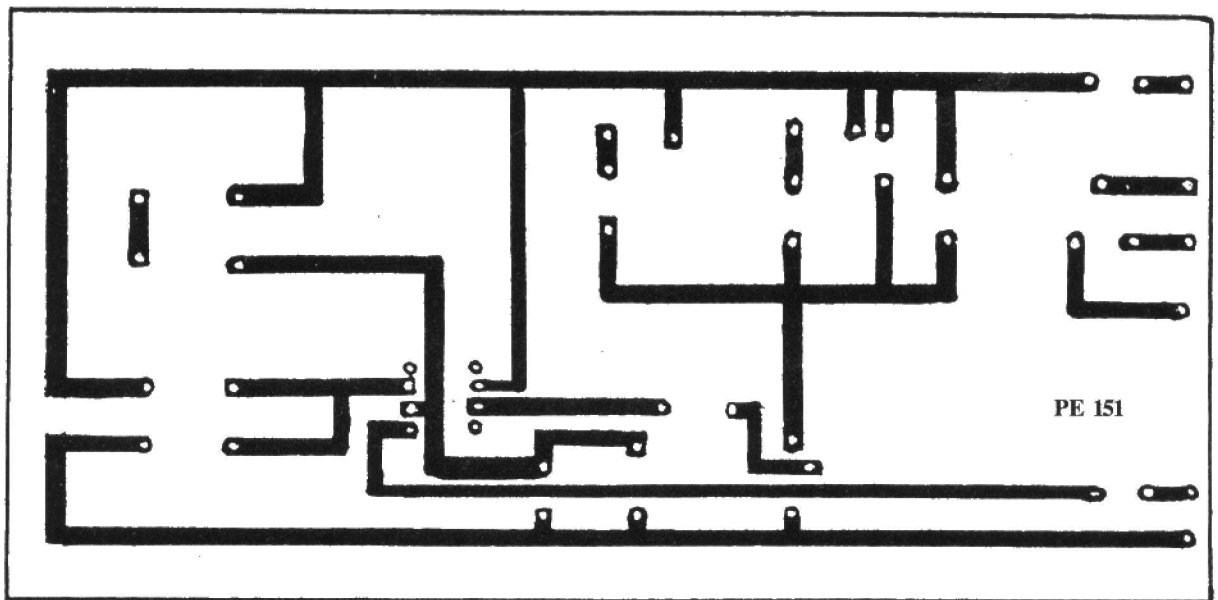
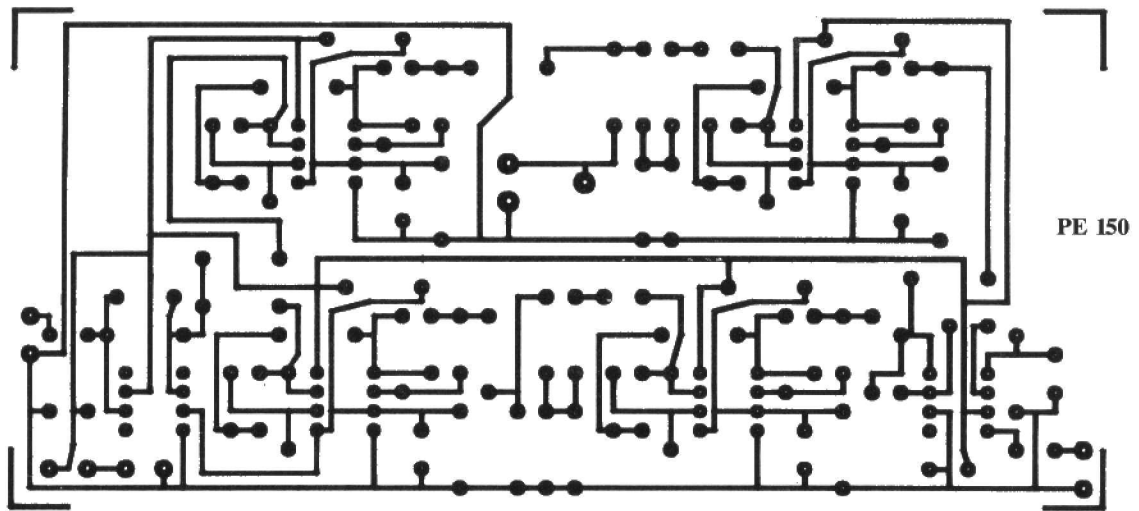
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HOW TO USE THESE TRACKS

FIRST MAKE TRANSPARENT COPY

(We regret that we cannot supply transparent copies of PCB track layouts.)

STUDIO COPY METHOD

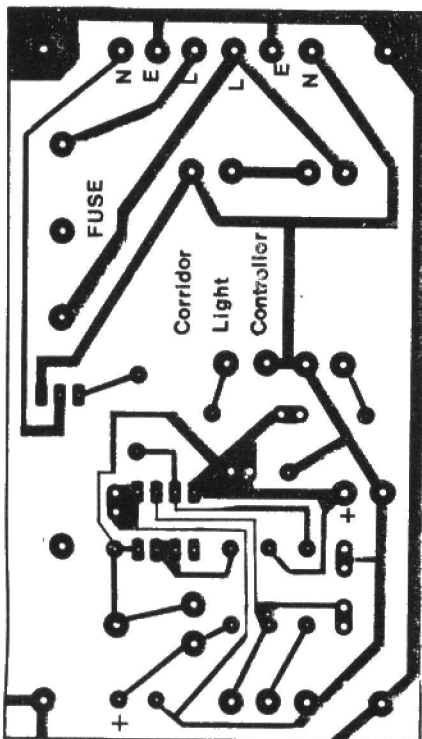
Ask local photographic studio to produce high contrast 1 to 1 positive transparency.

HOME PHOTOGRAPHY METHOD

Using even, bright illumination, photograph track onto fine grain black and white negative film. Develop film for high contrast. Photographically enlarge image up to lifesize, and print onto high contrast lithographic cut film, such as Agfa Copyline HDU 3P Type 2. Develop in Agfa Litex G90T litho developer, or similar.

PHOTOCOPY METHOD

Ask local photocopy shop to make a good contrast copy onto acetate film.



BORDERING ON SIMPLICITY

GIVE THE PROFESSIONAL TOUCH TO YOUR ASSEMBLY - BUY YOUR PCB FROM THE PE PCB SERVICE - READY MADE, FULLY DRILLED AND ROLLER TINNED.

(Some copiers are better than others - shop around.) Then touch up tracks with dense black ink, or photographic opaque ink.

ISODRAFT METHOD

Have a normal photocopy made, ensuring good dense black image. Spray ISOdraft Transparentiser onto copy in accordance with supplied instructions. ISOdraft is available from **Cannon & Wrin**, 68 High Street, Chislehurst, Kent. Tel: 01-476 0935.

PAINSTAKING METHODS

Draw image by hand onto clear film or drafting film using dense black ink. Draw direct onto copper surface of PCB fibreglass, using etch-resist inking pen. Use etch resist PCB tracks and pads, taping direct to copper surface, or onto drafting film.

NEXT PRINT ONTO PCB

Place positive transparency onto photosensitised copper clad fibre glass,

cover with glass to ensure full contact. Expose to Ultraviolet light for several minutes (experiment to find correct time - depends on UV intensity).

Develop PCB in Sodium Hydroxide (available from chemists) until clean track image is seen, wash in warm running water. Etch in hot Ferric Chloride, frequently withdrawing PCB to allow exposure to air. Wash PCB in running water, dry, and drill holes, normally using a 1mm drill bit.

(PCB materials and chemicals are available from several sources - study advertisements.)

*** CAUTION - ENSURE THAT UV LIGHT DOES NOT SHINE INTO YOUR EYES. PROTECT HANDS WITH RUBBER GLOVES WHEN USING CHEMICALS.**

ALTERNATIVE METHOD

Buy your PCB ready made through the PE PCB SERVICE, most are usually available - see page 60. **PE**

LEADING EDGE

Continued from page 8.

Philips would say only that "Our formal position is that we are not endorsing the CBS Copycode system".

Thorn-EMI shunted the question to EMI Records who were more positive. "This company is satisfied with the qualitative and technical assessment of CBS Copycode which has been carried out on behalf of the recorded music copyright owners by representatives of the IFPI, BPI (trade body for the British record companies), British Patent Office, DTI and the EEC Commission. The collective verdict is that, to all those listeners, Copycode encoding is inaudible and use of the Copycode system does not impair audio quality".

Well, it's nice to know that the future of hi fi reproduction rests with the golden ears of the IFPI, BPI, Patent Office, Government's Department of Trade and Industry and EEC eurocrats.

Because the IFPI is so keen on Copycode as a DAT-killer I asked Ian Thomas, Director General of the IFPI, what listening tests the IFPI had carried out to back up its unqualified reassurance that "the Copycode signal is inaudible and does not interfere with normal playback". Thomas says that "among those who have satisfied themselves in subjective tests as to the inaudibility of the system, are Government experts from the EEC member states, leading figures in the

recording studio world (including George Martin) and technical experts from Polygram and Philips, as well as CBS. In the United States, Copycode has been approved by the RIA Engineering Committee".

So, on the one hand, we have Philips saying it is neither endorsing Copycode nor not endorsing it while, on the other hand, we have the IFPI saying that technical experts from Polygram and Philips are saying that the system is inaudible.

It seems odd that Philips, who invented the compact disc to give the world super high fidelity reproduction, and Philips' subsidiary Polygram, who have pioneered CD pressing, should now be so happy about a system which sucks frequencies out of the recorded waveform. If Copycode is adopted, and reviewers rebel, then Philips, Polygram and the IFPI's leading figures in the recording studio world (including Beatles' producer George Martin who is now President of the Association of Professional Recording Studios) may find themselves with a lot to answer for.

To my simple mind the issue is really very simple. If Copycode is inaudible, as EMI, the IFPI, BPI, Patent Office, DTI, EEC Commission, Philips, Polygram, APRS President, and of course CBS, all believe, then why has there been no demonstration outside this closed circle of political axe-grinders and largely non-technical and non-musical bureaucrats? **PE**

An analogue function generator scores over an IC one in two important ways: firstly, it's more accurate, and secondly, you can see what it's doing.

PE FUNGEN

BY ANDREW ARMSTRONG AND RON KEELEY

More functional than a chip

ALTHOUGH you can buy a function generator on a chip these days, the purity of the output waveforms still leaves something to be desired, and you can't see how it works.

This circuit is built with ordinary components (with the partial exception of the op-amps, which are high-speed types) so every detail can be studied and analysed. Of course it also makes a useful piece of audio test equipment; the prototype has been used professionally, for setting up recording levels, and for testing experimental audio processing circuits.

THE CIRCUIT

Fig. 1 shows the block diagram, and Fig. 3 the entire circuit of the FunGen. The integrator, IC1, and comparator IC2 form a conventional oscillator arrangement. When the comparator output, IC2 pin 6, in high, IC1's output ramps down until it crosses the lower comparator threshold, at which point IC2 pin 6 switches low. This forces the integrator output to ramp up until the upper comparator threshold is crossed, switching IC2 pin 6 to a high again so that the integrator output ramps down ... and so on. Thus the output from the integrator is a triangular waveform, while the comparator output is a squarewave.

The comparator output must be symmetrical about 0V or else the integrator will charge at different rates in each direction. Transistors TR1 and TR2 are included so that the squarewave output swings evenly between the supply rails, as the LF357 alone would provide an asymmetric output; the 100p 'speed-up' capacitors ensure the transistors switch quickly, producing sharp leading and trailing edges to the square wave.

A uniform mark/space ratio is achieved by tweaking the power supply rails, using VR4 and VR5, to compensate for any slight difference in switching levels between the two transistors.

The triangle-to-sine wave converter is based on IC3; in effect, it bends and flattens the tops and bottoms of the triangle waveform. Transistors TR4, TR6 and TR8 switch at three points as IC3's output swings high, gradually increasing the feedback to pin 2 and therefore reducing the gain. Transistors TR3, TR5 and TR7 provide the same function when IC3 pin 6 swings low.

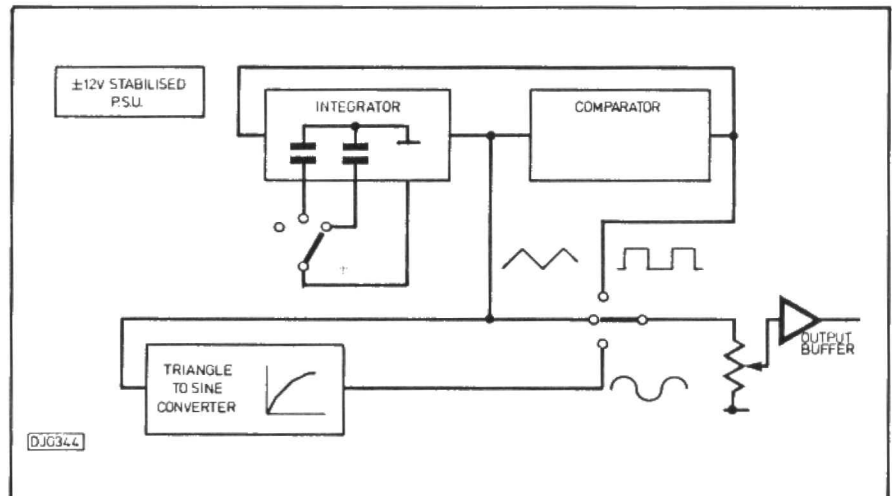


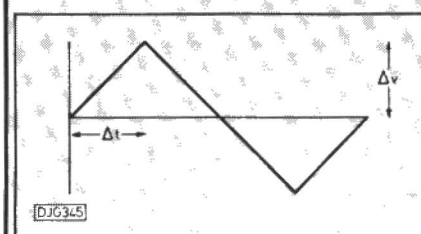
Fig. 1. Block diagram of the FunGen

Finally, the desired output – triangle, square or sine – is selected by S2 and buffered by IC4, which is configured as a unity-gain amplifier.

For those interested in mathematics and formulae, Fig. 2 shows some of the theoretical considerations.

CONSTRUCTION

The FunGen is easily constructed on the printed circuit board, following the layout shown in Fig. 4. Insert and solder all the passive components first, then the transistors and diodes, and finally the integrated circuits, which may be



The integrator output changes by ΔV in time Δt (ΔV is how far out the comparator switch points are from the 0V rails).

The standard formula for an integrator is:

$$\frac{\Delta V}{\Delta t} = \frac{-V_{in}}{RC} \Rightarrow \frac{1}{\Delta t} = \frac{V_{in}}{\Delta V} \times \frac{1}{RC}$$

NOW, from the graph we see that

$$F = \frac{1}{4 \times \Delta t}$$

ALSO, given the feedback resistor

values, $\frac{V}{\Delta V}$ is a fixed ratio regardless of power supply.

$$\frac{V}{\Delta V} = \frac{150K}{22K} = 6.818$$

$$\text{SO } F = \frac{1}{4 \times \Delta t} = \frac{V}{\Delta V} \times \frac{1}{4} \times \frac{1}{RC}$$

Rearrange to give frequency for any given resistance, given C.

$$R = 1.7045 \times \frac{1}{FC}$$

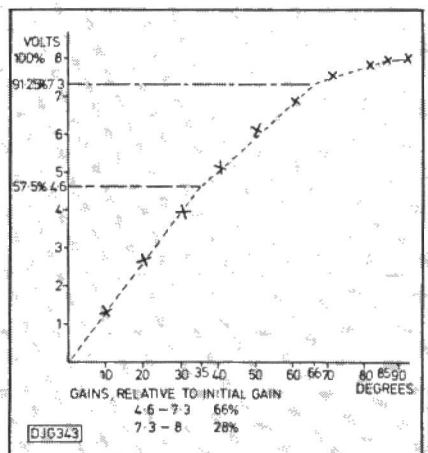


Fig. 2. Theoretical considerations

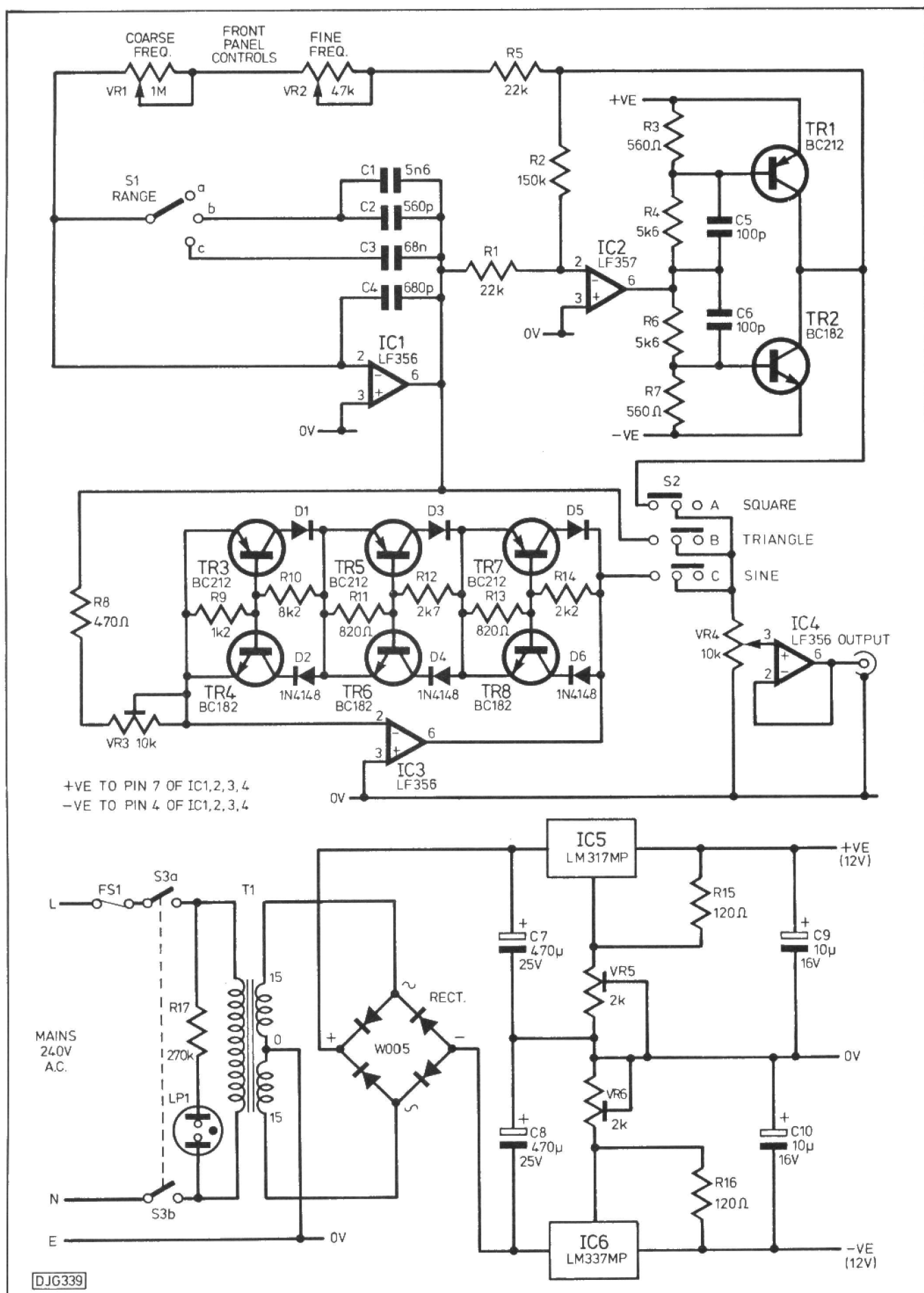


Fig.3. Circuit diagram of the complete FunGen

socketed if required. Observe the usual precautions when soldering, avoiding overheating and bridged tracks.

The power supply is built on a separate board for convenience and should be checked carefully before switching on - 240VAC is not to be taken lightly.

When the PSU has been built and tested, and the main board checked, temporarily wire up the off-board components S1 and S2, VR1, VR2 and VR6, and connect the power supply. Assuming everything works, VR1 and VR2 can be set for a frequency around 400Hz (much less wearing on the ears if prolonged testing is necessary).

The triangle and squarewave outputs should be immediately apparent. Ideally an oscilloscope should be used to set the

COMPONENTS

RESISTORS

C1	5n6
C2	560p
C3	68n
C4	680p
C5,6	100p (2 off)
C7,8	470µ/25V (2 off)
C9,10	10µ/16V (2 off)

POTENTIOMETERS

VR1	1MR
VR2	47k
VR3	10k min hor 12 preset
VR4	10k log
VR5, VR6	4k7, min hor 12 preset (2 off)

CAPACITORS

C1	5n6
C2	560p
C3	68n
C4	680p
C5,6	100p (2 off)
C7,8	470µ/25V (2 off)
C9,10	10µ/16V (2 off)

SEMICONDUCTORS

IC1, IC3, IC4	LF357 BiFET op-amps (3 off)
IC2	LF357 BiFET op-amp
IC5	LM317MP
IC6	LM337MP
TR1, TR3, TR5, TR7	BC212, PNP (4 off)
TR2, TR4, TR6, TR8	BC182, NPN (4 off)
D1-D6	1N4148 (6 off)
Rect	W005 Bridge Rectifier

SWITCHES

S1	3-pole rotary
S2	3-pole interlocked
S3	2-pole on/off, mains-rated

MISCELLANEOUS

LP1	neon indicator
T1	15-0-15V/3VA PCB mount

Case to suit, nuts, bolts, solder, hook-up wire, etc.

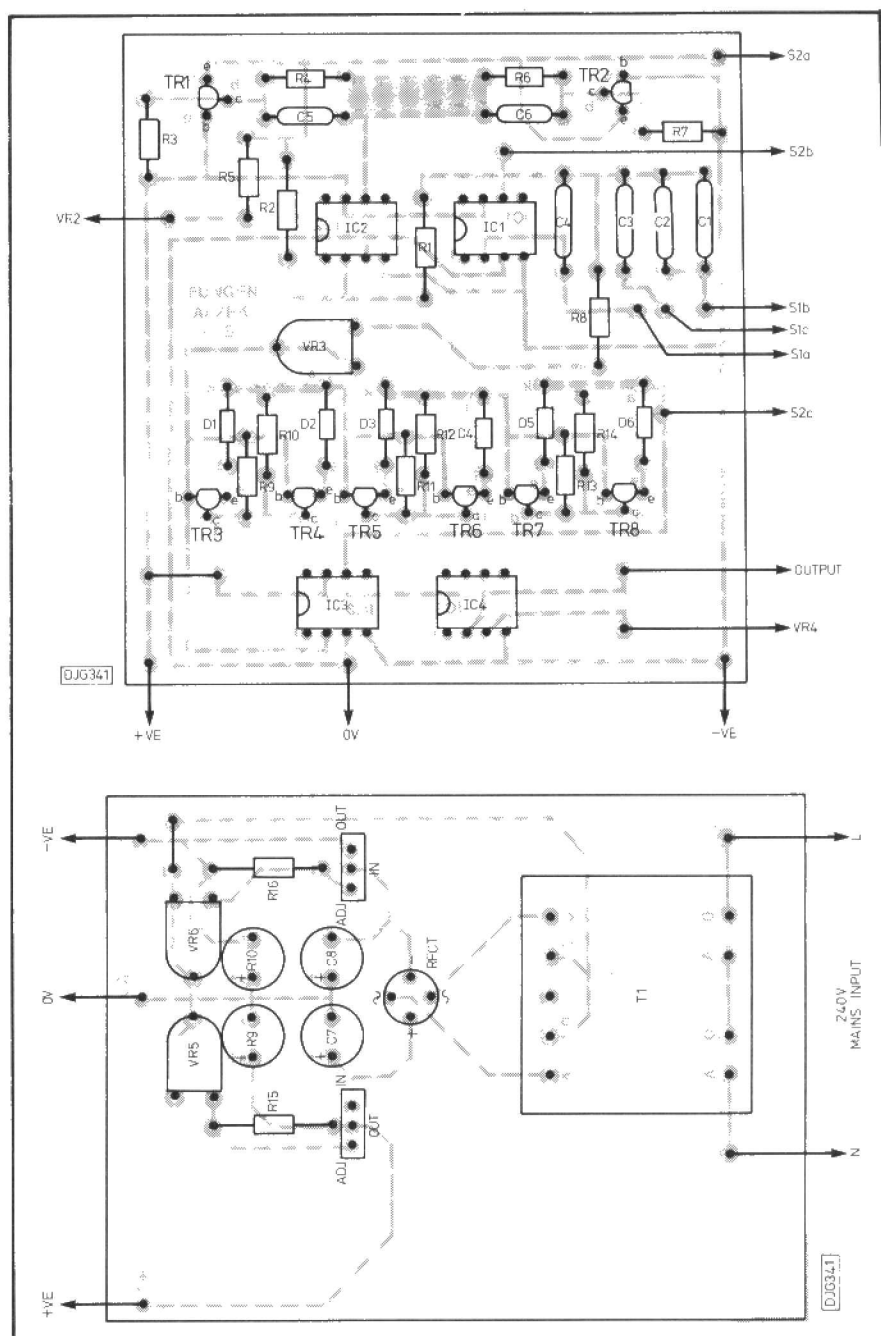


Fig.4. PCB's for the main circuit (Top) and PSU (Bottom)

comparator mark/space ratio and output swing. If one is not available, the best that can be done is to set up by ear! Back off the sine wave output using VR3, then slowly increase drive to the triangle-to-sine converter until the output is clearly audible.

Now any asymmetry in the comparator output will result in distortion of the sine wave - which can be detected more easily than by listening to the naturally harsher square or triangle wave tones. Adjusting the PSU trimmer potentiometers VR4 and VR5 will have an immediate effect on the quality of the sine wave output, and by trial and error they can be set for a minimum audible distortion.

Finally, turn up the drive to IC3 until distortion is once more apparent, then back off a little way. This produces the

greatest undistorted sine wave.

A case has not been specified for this project, but if a metal one is used, be sure to earth it securely.

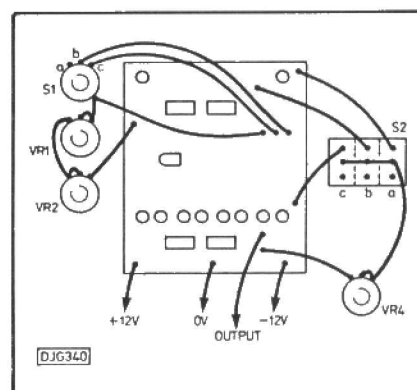


Fig.5. Control wiring


```
10 LPRINT "Frequency kHz Resistance k"
20 C=6.8E-10:CONST=1.7055
30 F=3000:GOSUB 70
40 FOR F=5000 TO 50000: STEP 5000
50 GOSUB 70
60 NEXT F:END
70 R=CONST/(F*C)
80 LPRINT USING " ££ £££.£";F/1000,R/1000
90 RETURN
```

Frequency kHz	Resistance k
3	836.0
5	501.6
10	250.8
15	167.2
20	125.4
25	100.3
30	83.6
35	71.7
40	62.7
45	55.7
50	50.2

Program to calculate pot
resistance V frequency
NB — resistance is total
resistance of both pots and
R5

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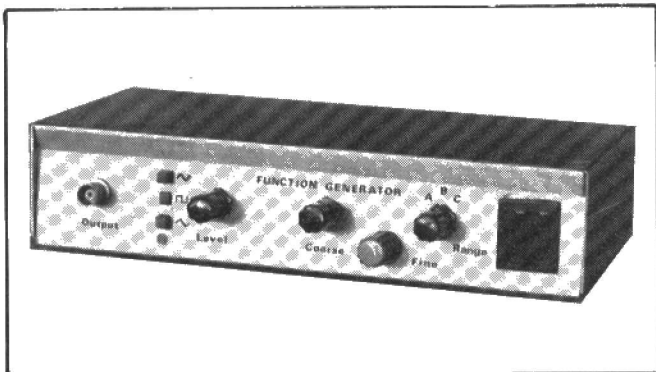
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PHOTOGRAPH OF AUTHOR'S BOXED
PROTOTYPE UNIT



BINARY CHOP - PUZZLE NO 6

TEST YOUR POWERS OF LOGICAL DEDUCTION AND WIN 12 MONTH'S SUBSCRIPTION TO PE!

BINARY CHOP - PUZZLE NO 6

DECODE THIS 294 CHARACTER MESSAGE

THE SERIAL BINARY DATA CONVERTER OMITTED ALL LEADING ZEROS!
LETTERS A TO Z = ASCII 1 TO 26. NUMBERS 0 TO 9 = ASCII 48 TO 57.
COMMA = ASCII 44, FULL-STOP = ASCII 46, NO OTHER CODES ARE USED.

```
111001011110111010010001011011110011010011100010110011111110010110
11101111100111111011111001111100101111110011111101111111001111
11011111101111100011100111111100111111100111111010111110111111
1001111111010111001011111110101111110100110001110101111110011111
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100011101001111110101110001110010111111010111110111000111010011111
100011000111010111000111001111111100111111000111000111001111000111
0100110001110011110010101
```

ANSWER TO BINARY CHOP PUZZLE 4

APPLY LOGIC AGAIN. SIMILAR TO PUZZLE 2. EACH NUMBER 0 TO 9 APPEARS FIVE
TIMES, BUT EACH ALPHA CHARACTER ALSO APPEARS TWICE.

0N4750C1YFL94202D37308U50YL2Z8S19U5K841PAJ3350966TMXZ2RVI33ENHVHPS1J0
60674F751264MR7TA0QE3M08481EBDKC

Send your answer to The Editor to arrive
before 1st September 1987.

12 month's subscription to Practical
Electronics will be awarded for the first
three correct answers opened. The
Editor's decision is final.

Answer in the November 1987 issue.

Winners!

Astonishing — No one submitted a
correct answer to Binary Chop No. 4 —
I didn't think it was *that* hard!

After much paging through program
listings I am pleased to inform

D.O. Wright of Sheffield
Michael Blain of Hemel Hempstead
E. Bergstrom of Rothley

That they are the winners of the program
competition announced in the June 1987
issue. Congratulations to all three.

CORRIDOR LIGHT CONTROLLER

BY GILES READ

A modest delay can make the journey easier

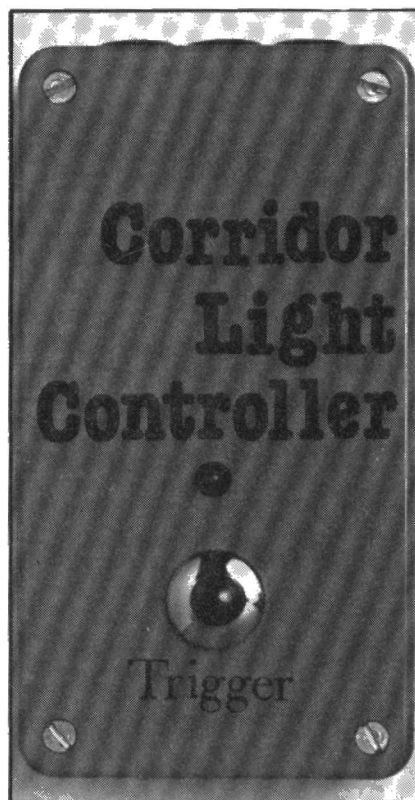
This is a self-cancelling light switch which uses a 555 to provide temporary illumination in a number of applications.

How often have you crawled into bed at the dead of night, only to groan inwardly as you have to get up again to switch the landing light off? In many continental hotels, especially in France, landing and corridor lights are controlled by a mechanical timer. Beside each door is a small illuminated push switch which triggers the timer and switches on the lights for a predetermined length of time, usually a couple of minutes or so. The results are a saving in electricity because the lights aren't on all the time, and of course contented guests who can see their way about. Unfortunately, the mechanical units are expensive, sometimes unreliable and usually tick loudly while the lights are on, much to the annoyance of anyone within earshot.

In these enlightened times (pun intended) a solid-state approach is more convenient and cheaper. The corridor light controller described here is capable of switching up to about 500W of incandescent lighting (100W without a heatsink on CSR1). It also features an unlimited number of switch points and an adjustable delay time. Above all it doesn't tick!

CIRCUIT DESCRIPTION

After serious trouble with the 37MHz memory timing signals of the original 32-bit microprocessor-based circuit, an analogue approach was adopted. (*It must have been a Read error! Ed.*) The



heart of the circuit is the ubiquitous NE555 timer IC in its monostable configuration. Timing capacitor C3 is shown as 47 μ , though values from around 10 μ to 220 μ give useful timing ranges, adjusted by VR1. A value of 47 μ

for C3 gives and active period of around a couple of minutes which is adequate in most cases.

The power supply arrangement is nothing special, just a small 3VA transformer the output of which is rectified by D1 and D2, and smoothed by C1. Any nasty spikes on the DC supply are dealt with by C1. C5 helps to deal with the high current drain caused by IC1 when its output changes state. For those who don't know about the 555's bad habits, because of the way the chip's output circuitry is designed, the output transistors momentarily short-circuit the supply rails every time they turn on or off. The resulting current pulse can cause all sorts of trouble (such as false triggering) if it isn't taken care of with a capacitor close to the supply pins.

The timer's output drives a C206D triac, via a current-limiting resistor, R4. A LED is also connected (via another current limiting resistor, R3) to indicate the electronic delay switch's state. Because the triac is not isolated by an opto-coupler, the circuit's negative supply rail is connected to mains neutral to provide a return path for the drive current.

CONSTRUCTION AND TESTING

Start construction with the resistors and diodes, followed by the capacitors, LED and IC. Do not fit the transformer or connect the lamp or the mains at this stage. Connect a push switch to the

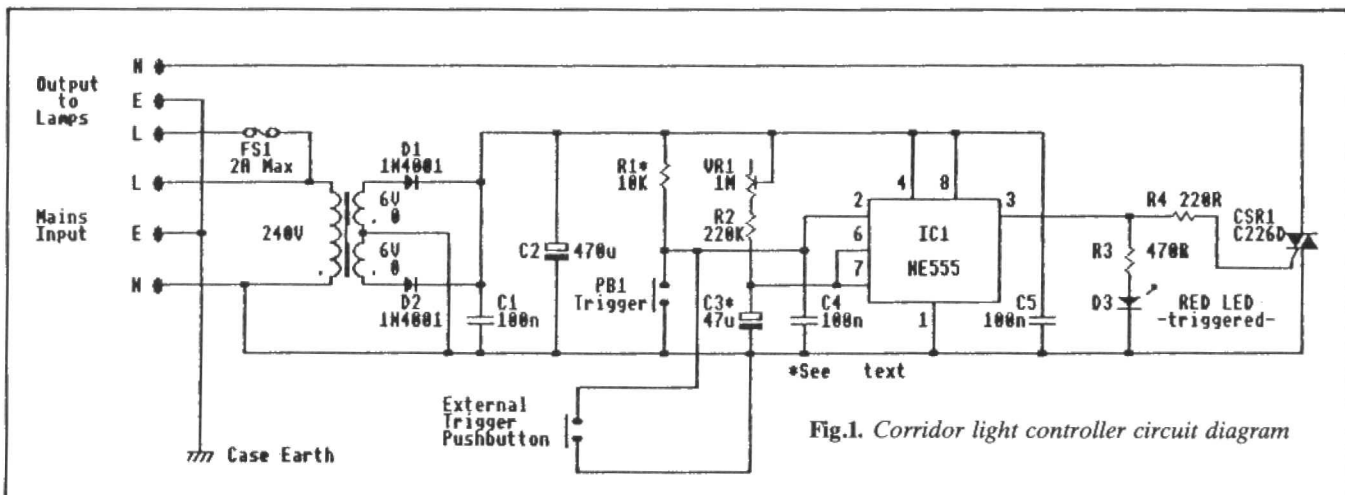


Fig.1. Corridor light controller circuit diagram

COMPONENTS

RESISTORS

R1	10K
R2	220K
R3	470R
R4	220R

All resistors 10% or better

POTENTIOMETER

VR1	1M min horiz preset
-----	---------------------

CAPACITORS

C1	100n
C2	470µ 16V
C3	47µ 16V (see text)
C4, C5	100n (2 off)

SEMICONDUCTORS

IC1	NE555
D1	1N4001
D2	1N4001
D3	Red LED
CSR1	C226D

MISCELLANEOUS

SPST push switch, 20mm PCB mounting fuseholder, suitable fuse (1A max.), 3-way PCB mtg screw terminals (3 off), 6-0-6VPCB mounting 3VA transformer, small heatsink for CSR1 (only required if more than 100W of lamps are connected), plastic case approx. 120x65x40mm to suit. Suitable low-current connecting wire. Also required for each additional switch point: 1 small plastic box, 1 SPST push switch. Extra parts for pilot light in remote switch: BZY88C4V7, Red LED, 1K ¼W, and change R1 in main circuit to 470R.

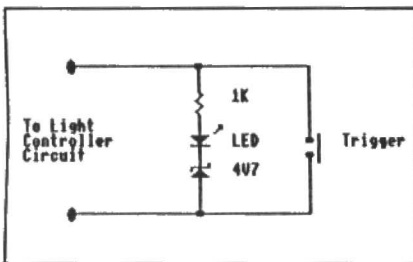


Fig.2. Circuit of illuminated remote trigger for corridor light controller

appropriate point on the PCB, and apply about 6V to 9V between the neutral pin and the junction of D1 and D2. VR1 should be set fully anti-clockwise to set the delay to a minimum for test purposes. If the LED lights when the power is applied then leave the circuit alone for a couple of minutes – it should go out eventually. When the LED has extinguished, press the push switch. The result should again be an illuminated LED. The ON time can be adjusted by VR1, but unless there is a need to set to mid-travel. Disconnect the power from the circuit and fit the transformer.

BEWARE – FROM NOW ON THE CIRCUIT BOARD AND CONNECTING WIRES MUST BE CONSIDERED POTENTIALLY LETHAL WHEN CONNECTED TO THE MAINS. BE VERY CAREFUL WHEN TESTING THE UNIT, AND IF IN ANY DOUBT CONSULT A QUALIFIED ELECTRICIAN.

LOW-VOLTAGE USE

It is possible to modify the circuit to work as a low-voltage switch, perhaps as a car courtesy light extender, running from 12V. Simply omit the transformer and D1, replace D2 with a 10R ½W resistor, CSR1 with a BD131 on a heatsink and change R4 to 470R. Link the PCB pads between what was the transformer's

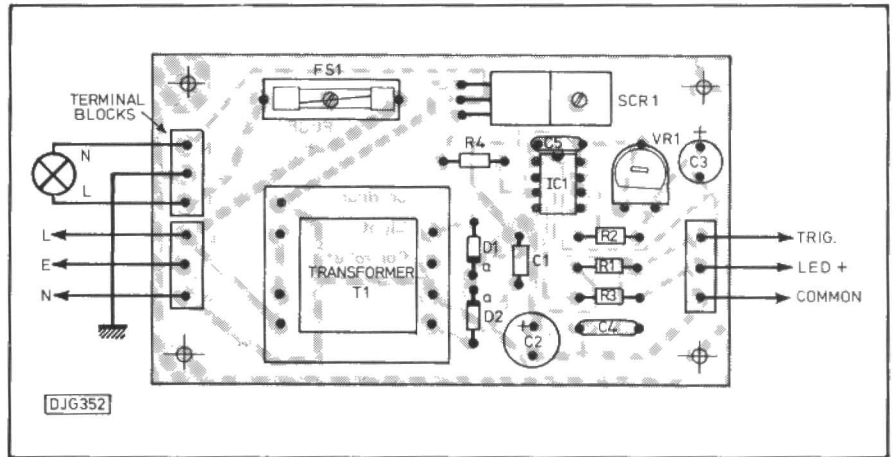


Fig.3. Printed circuit board details

Fit the board into a suitable plastic case, connect the lamp(s) that are to be controlled and add as many push switches as required in parallel with the one shown on the diagram. Each switch MUST be fully encased, as its terminals will be connected to the mains.

As an extra refinement, the extension push switches can be fitted with pilot lights to enable them to be found easily at night. Fig.2. The trigger input on the NE555 (pin 2) has to go below one third of the supply voltage before it will trigger. The supply rail in the circuit runs at 9V, which means that there is potentially 6V sitting on the trigger inputs – more than enough to run a LED. In order to take any current from the circuit though, pull-out resistor R1 must be changed to a lower value; 470R is suitable. Taking the extra circuitry in the remote switch from the top, the 1k resistor limits the current through the LED, and the zener diode ensures that the voltage dropped across the assembly can't drop below about 6.2V (4.7V + about 1.5V forward voltage of a red LED). The construction of the extension is shown in Fig.4.

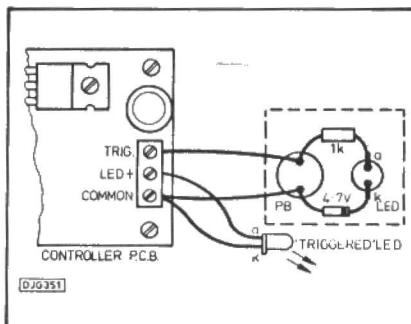
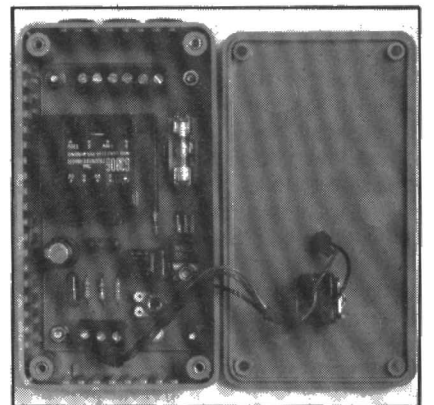


Fig.4. Wiring to extension unit

Live connection and the pin connected to the new 10R resistor. Previous Live point, common to 0V. The lamp connections are unchanged.

The lamp must draw no more than about 2A (24W at 12V in order to avoid overheating the power transistor. If the circuit is used as a courtesy light extender then the wire from the door switch should be connected to R1. The lamp should then be connected to the line from the transistor's collector. The value of C2 will probably need changing to about 4µ7 or 10µ in order to give a reasonably short delay, otherwise the lamp could stay on for the first ten miles or so!



AND FINALLY

The use of the mains circuit is not limited to hotel corridors and house landings, of course, but if an outdoor switch is contemplated, then bear in mind that the switch and housing used MUST be waterproof to at least IP67. Doorbell switches are definitely NOT suitable.

PE

This month Graham Nalty discharges his stored knowledge of capacitor characteristics, and takes a brief look at semiconductors.

COMPONENT TECHNOLOGY

PART TWO BY GRAHAM NALTY

Changing components with military precision – a sound decision

Much more has been written in various technical publications about the effects of capacitor quality on the sound quality of a system than has been written about resistors. The capacitor is a more complex component. In its simplest form a capacitor consists of two plates of cross sectional area A and spaced a distance d apart. The value of the capacitor is

$$C = \Sigma_0 \frac{A}{d} \text{ Farads}$$

where Σ_0 is the permittivity of air.

In real life a single parallel plate capacitor is not a very practical proposition. The capacitance would be too small for most applications. The nearest equivalent is the variable parallel plate tuning capacitor used in radios. Even with a number of plates in parallel, the maximum capacitance is only about 500pF.

The value of the capacitor can be increased by placing between the plates a material of a higher dielectric permittivity than air. The capacitance of a parallel plate capacitor with a dielectric permittivity Σ is:

$$C = \Sigma \Sigma_0 \frac{A}{d}$$

The higher the dielectric permittivity, the higher the value of the capacitor that can be obtained in a given size.

In real life there are many different types of capacitor dielectric used and these are shown in Table 2.

The most obvious point from this table is that small value capacitors have the lowest power loss. This may seem strange at first. For example the power loss in power transformers lowers proportionately with increasing size. In the case of power transformers, the greater the size, the greater incentive there is for lower power loss. In the case of capacitors, smaller value ones are easier to make and are physically smaller. The result is a greater choice of dielectric available in order to produce a capacitor of a commercially practical size and price. A 1nF polystyrene capacitor may cost the same as a 10nF polycarbonate, or a 100nF polyester or a 1μF tantalum of 10μF aluminium electrolytic. And in terms of physical size, there is not a great deal of difference either.

Before I go on to describe different types of capacitor in detail, I would like to make two general statements. The

Dielectric	Range of Values	Power Loss
Aluminium Electrolytic	1μF–33,000μF	0.08–0.2
Solid Aluminium	22μF–220μF	0.15
Tantalum Electrolytic	0.1μF–100μF	0.06–0.2
Ceramic	10pF–1μF	0.015–0.03
Polyester	1nF–10μF	0.01–0.015
Polycarbonate	10nF–4.7μF	0.003–0.005
Silver Mica	10pF–10nF	0.0015–0.003
Polypropylene	220pF–10μF	0.0004–0.0015
Teflon	330pF–2.2μF	0.0005–0.001
Polystyrene	10pF–100nF	0.0003–0.0005

Table 2. Typical characteristics of different capacitors.

Source: RS components catalogue with additional information from manufacturers' literature.

first is that capacitors of lower power loss sound better than those of higher loss dielectric, and the second is that components designed for higher performance (e.g. long life electrolytics, close tolerance polypropylenes and polystyrenes designed for filter circuits etc) generally sound better than their 'commercial' or 'industrial' equivalents.

In any audio amplifier (or other electronic unit) there are a large number of capacitors, each carrying out one of the following functions:

- a) Power supply reservoir
- b) Amplifier or regulator stability compensation
- c) Power supply decoupling
- d) DC blocking between amplifier stages
- e) Altering frequency response in equalisation, tone control or filter circuits.

ELECTROLYTICS

Power supply reservoir capacitors carry out two functions. Firstly they take the pulsed rectified waveform and convert that energy into a steady direct vol-

tage. Secondly, they supply the amplifier circuits with the current they require to drive the audio signal to the loudspeakers. Reservoir capacitors are big and expensive and because of the very large values required to provide the power to drive loudspeakers, we have very little choice in the type of dielectric that can be used.

In Table 3 I have listed some of the main specifications of different type of reservoir capacitor. For ease of comparison, I have taken the specs of a 10,000μF 40V capacitor, this being the value used in the higher power version of the PE 30 + 30.

The aluminium electrolytic capacitors consist of two aluminium foils interleaved with an absorbent paper and wound tightly into a cylinder. Contact is made by tabs of aluminium attached to the foils. The winding is then impregnated with electrolyte and placed in an aluminium can. A dielectric layer of aluminium oxide is formed electrolytically on the surface of one aluminium foil which acts as the positive plate. The electrolyte serves as the second plate and

Manufacturer	Type	Ripple Current 100Hz, 85°C	E.S.R. 100Hz, 20°C
LCR	FAC/CW	4.3A	
LCR	FAC114 ULL	8.1A	
Mullard	114	7.5A	
Mullard	050	4.0A	
BHC	ALP10	4.8A	37 m ohm
BHC	ALS10	6.0A	34 m ohm
BHC	ALS20A	8.8A	16 m ohm

Table 3. Specification of different types of 10,000μF 40V capacitors.

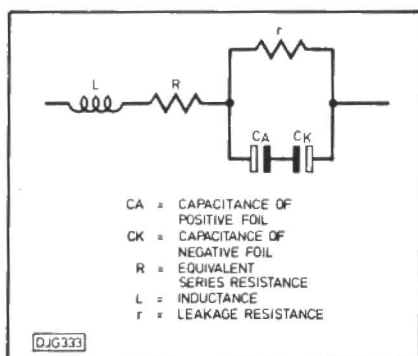


Fig. 6. Equivalent circuit of electrolytic capacitor

the second foil contacts the electrolyte reducing the series resistance. Since this foil has a thin oxide film due to natural atmospheric oxidation, it will possess a very high capacitance. Both foils are usually etched to produce a convoluted surface, greatly increasing the surface area. As a result, the aluminium capacitor has a very large capacitance per unit volume.

The simplified equivalent circuit of an electrolytic capacitor is shown in Fig. 6. The effective capacitance C is the equivalent series capacitance of C_A and C_K . The Equivalent Series Resistance (ESR) is made up of resistance due to the electrolyte and foils, the resistances of connections and the equivalent resistance due to dielectric loss. Inductance is due to the lead wires, tab connections, and the element windings. The effect of inductance on capacitance performance at high frequencies is shown in Fig. 7. Leakage resistance is usually specified as a leakage current and is typically 2.4mA for BHC ALS10 and 1.2 mA for BHC ALS20A capacitors rated at 10,000 μ F 40V.

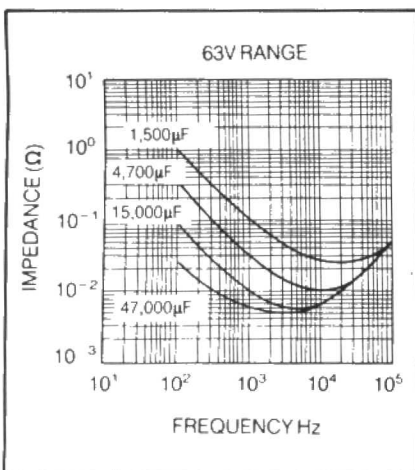


Fig. 7. Impedance of BHC ALS 20A capacitors with frequency

The value of capacitance of an electrolytic capacitor changes significantly with temperature. From Fig. 8, a typical 40V capacitor will exhibit a temperature coefficient of 1200 ppm/ $^{\circ}$ C.

In sonic terms, the aluminium electrolytic capacitor is of the lowest quality, but we have to use them because there is no other way to obtain the high values

we require for power supply smoothing. Our problem is to find ways to improve the sonic performance of large reservoir capacitors. One solution to the problem that has been tried quite successfully is to use slit foil windings. This has been tried by a British manufacturer who markets them under 'FILMCAP DNM' brand. Based on the ideas of Denis Morecroft, designer of the outstanding DNM preamps, this method of construction is claimed to offer sonic advantages at a very small extra cost and these capacitors are creating quite a bit of interest amongst audio constructors.

BYPASS IMPROVEMENT

There is a way in which the performance of electrolytic reservoir capacitors can be improved and that is by bypassing them with capacitors of a smaller value, and higher quality (i.e. lower dielectric loss) construction. For example, a 10,000 μ F reservoir capacitor might be bypassed by a high quality 100 μ F electrolytic, a 1 μ F film type of the highest available quality (ideally a Wonder Cap) and a 10nF polystyrene. The effect of bypassing large capacitors with smaller types is to improve the sonic performance at high frequencies. Whilst such effects are clearly audible, it is not easy to give a fully plausible explanation. It is obvious from the curves in Fig. 7 that the performance of very large capacitors at the very highest audio frequencies leaves a lot to be desired due to their inductance, which causes the impedance to rise with frequency below 10kHz, but this impedance is still much lower than the impedance of the capacitor used to bypass it. Choosing the right value of capacitor to use as a bypass is very much an art to get the best results, but I myself generally work around a value about 1% of the capacitor to be bypassed.

An essential feature of amplifier or regulator design is to maintain high frequency stability. The usual method is to place a capacitor at a suitable point. In sonic terms the output capacitor of IC regulators is perhaps most critical because it also supplies the audio circuit directly. Only in very few cases are problems likely to be encountered in the choice of capacitor.

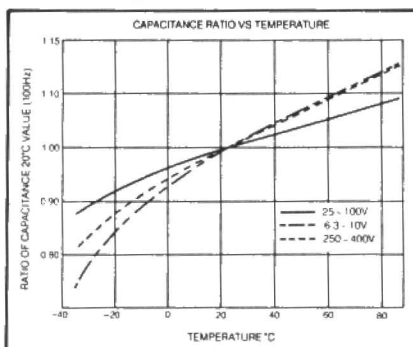


Fig. 8. Effect of temperature on aluminium electrolytic capacitors

Capacitors used in power supply decoupling are generally of the order of 100 μ F and aluminium electrolytics are the most suitable. If improved performance is required at high frequencies, bypassing is a good idea. If improved performance at low frequencies is the objective, then it would be better to change to a regulated supply.

DC BLOCKING

The audio signal passing through an amplifier passes through several DC blocking capacitors. In single power supply amplifiers, the full output signal passes through a large electrolytic capacitor. This situation is far from ideal, but its effects can be reduced by bypassing it and taking the main negative feedback loop round it, as shown in Fig. 9.

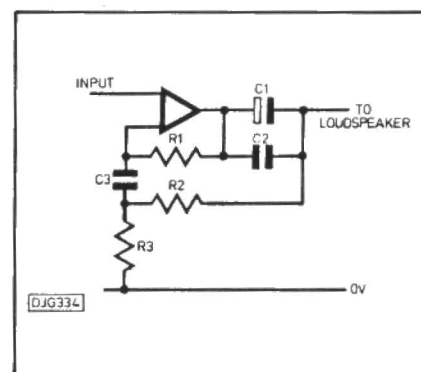


Fig. 9. Single rail power supply amplifier

R_1 is a very high value resistor which maintains DC feedback, and C_3 is a high quality film capacitor which takes the AC feedback from R_2 to the feedback input. As the audio signal passes through each DC blocking capacitor, each capacitor must be of the highest sonic quality. In all instances the design compromise is between cost, capacitor quality and low frequency extension. The low frequency response is determined by the input impedance of the next circuit and the value of capacitor. Increasing the impedance of the next stage either extends low frequency response, or enables a smaller value blocking capacitor to be used. The smaller the blocking capacitor, the lower cost or higher performance of the actual device that can be used. As with reservoir capacitors, the extreme high frequency performance of larger DC blocking capacitors can be improved by bypassing.

EQUALISATION

Where changes in the frequency response of an amplifier is required, capacitors are used far more often than inductors. This is because it is far easier to obtain capacitors to close tolerance exact values than inductors. However, I am certain that many readers would claim that getting close tolerance capacitors is difficult enough. In practice it is quite easy to get close tolerance polystyrene capacitors up to 10nF, but it sometimes takes a bit of searching to

find a supplier of even 5% values over 10nF.

In audio design terms it may well be far more important to use higher sonic quality capacitors for equalisation and filter circuits than for blocking capacitors. When an audio signal passes through a blocking capacitor the voltage across the capacitor is very small compared to the actual signal voltage. In a filter or equalisation circuit the voltage across the capacitor may well be 70% of the signal voltage at the -3dB point. As a larger part of the audio signal is present across a filter capacitor than across a blocking capacitor it is probably likely to have more effect. However, in most circuits, values of filter and equalisation capacitors are lower than blocking capacitors, and the best practice is to use higher quality capacitors for the lower values. Fig.10.

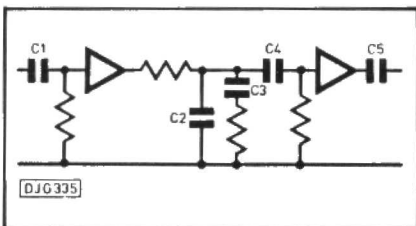


Fig.10. DC blocking (C1, C4, C5) and equalisation capacitors (C2, C3)

CAPACITOR VARIETY

In audio circuits you will find most kinds of capacitors in most applications. Aluminium electrolytics are used when cost is the main factor. Tantalum electrolytics are particularly useful where small size is important. Polyester capacitors are used where the advantages of plastic film dielectrics are required, and are by far the most commonly used film capacitor. Polycarbonate capacitors are very similar to polyester and have the advantage of improved high frequency performance, lower power factor and improved sound quality. In circuits other than audio, if you have any difficulty in obtaining polycarbonate capacitors a polyester capacitor of the same is an ideal substitution. Polypropylene, Teflon and Polystyrene are the high quality films. Polypropylene is used particularly for high voltage applications. It is also used for special capacitors designed for the highest quality audio, such as IAR Wonder caps, Siderealkaps and Chateauroux. Both Wonder caps and Siderealkaps are fitted with leads made of wires of the highest audio quality. Wonder caps leads are made from wonder wire, an uninsulated 0.8mm diameter wire, and Siderealkap leads from Kimber cable, multistrand leads of different sized cores with insulation of very low dielectric loss.

Polystyrene capacitors are used extensively in audio. Most of the types used are low cost and although they have an extremely low power factor should not automatically be expected to have the

highest sonic quality – possibly for reasons of care taken in manufacture and materials used. High stability polystyrene capacitors do appear to exhibit the highest sonic quality and I have used LCR types EXFS/RP with great success. Suflex type EXF have very similar specifications and I would expect them to be of comparable sonic performance.

Silver mica capacitors have very low loss and are useful where close tolerances are required. Ceramic capacitors should not be used in audio circuits.

Capacitors are used extensively in loudspeaker crossovers. In far too many cases, cheap low quality reversible electrolytics are fitted to some very expensive loudspeakers. It is incredible how much the sound quality of a loudspeaker can be improved by taking out reversible electrolytics and substituting polyester caps of the same value; and even more so by substituting Wonder caps or Siderealkaps. These ranges only go up to 10 μ F, but whilst the Chateauroux range goes up to 200 μ F higher values may not be easy to obtain. Even so, it is frightening how many well known speaker manufacturers still use reversible electrolytics.

One of the explanations put forward for the differences in sound quality in different types of capacitor is dielectric absorption. When a capacitor is charged, it absorbs energy. However, when it is later discharged some of that energy is not immediately removed, but stored in the dielectric. If a resistor is used to discharge the capacitor, then after the resistor is disconnected, the voltage across the capacitor terminals will rise due to the energy stored in the dielectric. The dielectric absorption of the capacitor can be calculated from the voltage rise at a fixed interval after a chosen charge/discharge cycle.

DEEPER UNDERSTANDING

In recent years, the emphasis on advances in audio quality has shifted away from low steady state distortion circuit design to a deeper understanding of the effects of passive components on sound quality. Put simply, it has been more of a better understanding of the quality of currently available technology and using it to advantage, than of developing new technologies to meet the requirements of audio designers. One area where technology has moved ahead to the benefit of the audio designer, but not primarily so, is the greater availability of gold plated switches and connectors. The prime mover in this instance has been the very rapid development of computer and information technologies. Accuracy of signals is of prime importance and the use of gold plated connectors gives a much greater reliability of the connection over a period of time. Whilst the computer engineer is only interested in making sure that the connection is made, the audio engineer is

interested in the quality of the connection. Both interests are shared because a connection that maintains its sonic quality is one that is less likely to fail outright.

SEMICONDUCTOR TECHNOLOGY

The semiconductor industry is one which is normally associated with technological developments, but some of the greatest improvements in audio quality yet to be achieved can be obtained through better understanding of the characteristics of current and also well established components. It is several years now since Hitachi introduced their outstanding mosfet power transistors. Whilst these have an extremely important part to play in power amplifier production, they have not overtaken older bipolar devices for amplifier output stages.

Semiconductors fall a long way short of being ideal amplifying devices, and because they are used without full understanding of their limitations the term 'transistor sound' has been used in a derogatory way, especially by those who prefer the sound of valve equipment.

It is not my intention at this stage to discuss digital audio. That is a completely separate subject with completely different problems from those of analogue audio. I would suggest that the analogue circuits in digital equipment need to be taken seriously if the full potential of digital recording is to be realised.

MOVING COILS

The output from a moving coil cartridge is extremely low and one of the problems in the design of input stages to match the cartridge, is to achieve very low noise in the amplifier. Low noise small signal transistors have a much higher base impedance than moving coil cartridges and are not ideally matched. One solution that has been tried in the past has been to use transistors designed for high current applications. Another solution has been to use several small signal transistors in parallel. Neither solution has been entirely satisfactory and devices have been developed in the Far East specially to provide ultra low noise amplification of moving coil cartridges.

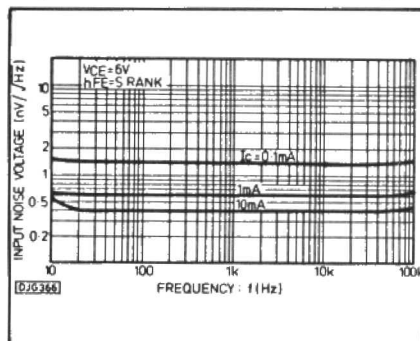


Fig.11. 2SD 786 (HFE 270-500)

Fig.11 shows the noise voltage of the 2SD786 npn transistor. At a collector current of 1mA, the input noise voltage is 0.6 nV/V^{1/2}Hz and even lower at 10mA. There is a matching pnp transistor 2SB737 with almost identical specification. These transistors use special passivation techniques to achieve a very low value of base spreading resistance of approximately 4 ohms in 2SD786 and 2 ohms in 2SB737. The manufacturers claim that using these transistors, a signal to noise ratio of 81dB below 125μV can be achieved in a MC preamp. Another characteristic of the 2SD786 is the comparatively constant current gain varying by only 50% over a current range from 1mA to 100mA collector current (Fig.12).

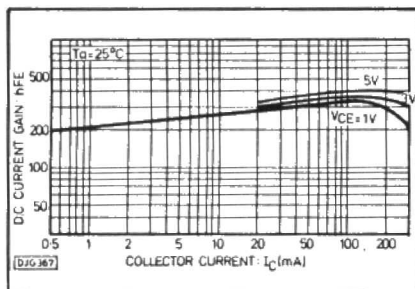
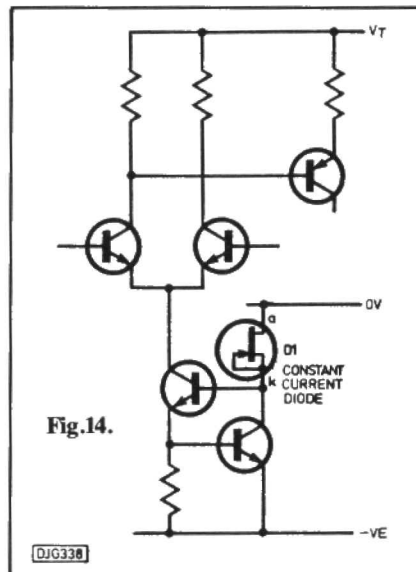
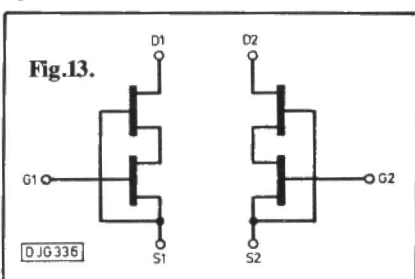


Fig.12. 2SD 786

Other low noise semiconductors of interest are LT1028 (0.85nV/V^{1/2}Hz) and MAT02FH and LM394 (1.8nV/V^{1/2}Hz). The LT1028 is a high speed op-amp from Linear Technology with an input offset voltage of 40μV. The MAT02FH and LM394 are high gain dual matched transistors with an input offset voltage of 150μV.

Matched transistors and op-amps with low offset voltages, especially if they have a low input base current, are very useful in high gain amplification circuits because quite often the number of DC blocking capacitors between MC cartridge and volume control can be reached.

In this application, bipolar transistors have a disadvantage because the output voltage offset will be changed by the change in input impedance when the source is connected to the input. Dual matched fets have the advantage that changes in the input loading will not affect the output offset voltage and are particularly suitable for the input of DC coupled power amplifiers. One device of particular interest is Intersil's IT500-503 cascode connected dual fets. Fig.13. Special features are common mode



rejection ratio of over 120dB and very low gate current.

Fet constant current diodes play a very useful part in improving amplifier sound quality. Their very high dynamic impedance enables power supply ripple rejection of a circuit to be substantially increased. Fig.14 shows a typical long tail pair, but by using a J500 series constant current diode, in place of the normal collector load resistor, the dynamic impedance of the constant current source feeding the long tail pair to changes in negative supply voltage is greatly increased. It would be possible to increase the dynamic impedance of Fig.14 by replacing the two transistor constant current source with a J500 series diode. However, the tolerance of these diodes is very wide and the reliable balance of currents in the long tail pair would not be equal.

JUNCTION EFFECTS

My own researches into audio amplifier design indicate that considerably observed distortion of the audio signal occurs due to the action of the audio signal itself heating the transistor junction, and thus causing changes in gain. The explanation that I gave earlier, in part one of the article on the effect temperature changes in resistors, applies here in a very similar way. The effect of changing a T092 small signal transistor handling the audio signal across its collector-emitter to a T0220 type with a metal tab is an obvious improvement despite the fact that parameters of gain and fre-

quency are greatly inferior. Such work points to the need for transistors which can combine the gain and frequency of a BC109C with the thermal resistance of a high power output transistor. Such products are not easily available and the nearest to these requirements are BUP30 (nnp) and BUP31 (pnp). Their parameters and characteristics are listed in Table 4.

I have on many occasions used BD139, BD140, TIP41A, TIP42A, BD243C, BD244C to replace small signal transistors with success, but have on more than one occasion encountered problems caused by extremely low current gains.

Temperature variations at transistor junctions do cause audible distortion. One way in which amplifiers can be improved is by close thermal tracking between the bias transistor and output transistors of a power amp. In a power amplifier with parallel multiple output transistors, each pair of output transistors should ideally have its own bias transistor. In other parts of an amplifier circuit, especially the input long tail pair, close thermal tracking can yield both sonic and other benefits (lower output offsets). Thermal design is a more important part of audio amplifier design than is generally realised. Greater reliability of output stages can be gained as well as better sound by the use of larger heat sinks.

One of the main limitations of power transistors is the very low F_t . Typical complementary output pairs used in high power audio amps may have F_t of 5MHz. Some NPN transistors (2N5038,9) have an F_t of 50MHz, but do not have a matching PNP. In Japan there are many types of power transistors up to 150W with F_t of 90 MHz, but these are not available in the UK. It would be nice to produce a power amp design for readers of PE using such transistors. Maybe that will have to wait for another day. In the meantime, as I suggest in this article, there is plenty of scope for improving the sound quality of audio amplifiers simply through a better understanding of the strengths and weaknesses of the components currently available.

ACKNOWLEDGEMENTS

Sources of information for this article include technical literature from the following companies: Holsworthy Electronics, Vishay, BHC, Semelab. **PE**

Type	BUP30	BUP31	
Polarity	NPN	PNP	
VCBO	60	60	volts
I_C peak	20	20	amps
P_T	50	50	watts
H_{fe} min $I_C = 1A$	70	70	
F_t	120	150	MHz

Table 4. Ratings and characteristics of BUP30 & BUP31



OUR REGULAR LOOK AT ASTRONOMY

SPACEWATCH

BY DR PATRICK MOORE OBE

As Voyager 2 draws nearer to Neptune, an even rarer cosmic event is sending data to us from another galaxy.

EVEN if it did no more, Voyager 2 would still be regarded as one of the most successful space-probes of the twentieth century. It has already obtained high quality pictures of Jupiter, Saturn and Uranus, together with a vast amount of miscellaneous information — it has out-classed its twin, Voyager 1, whose really useful career ended with its pass of Saturn and Titan (though let it be added that Voyager 1 is still fully functional, and we hope to keep in contact with it until it reaches the heliopause — that is to say, the edge of the area in which the Sun is dominant and beyond which the solar wind ceases to be detectable).

Voyager 2's next and final target is Neptune, the outermost planet, which is similar to Uranus in size and mass but has many points of dissimilarity. On 13 March, the rocket engines of Voyager 2 were fired for the fifteenth time to make sure that all is well for the Neptune rendezvous. It is now scheduled to pass

29,140 km (18,100 miles) from the centre of Neptune at 4 hours G.M.T. on 25 August 1989. This means that it will skim a mere 3000 miles from the Neptunian clouds, and will pass over the planet's north pole, after which it will pass 38,000 km from the surface of Triton, the senior of Neptune's two known moons. Triton may have a reasonably dense atmosphere, and is certainly a fascinating world. Unfortunately Voyager 2 will not pass much within three million miles of Nereid, the smaller satellite, and we can only hope to obtain reasonable images; can Nereid be like that strange attendant of Uranus, Miranda? Also, does Neptune have a ring? The presence of Triton, which moves in a retrograde orbit, seems to indicate that no extensive ring system is likely, but we certainly cannot be sure.

It is a pity that Pluto is out of Voyager 2's range, and that it will be the only planet to remain unvisited by the end of the 1990s.

In the Canary Islands, the William Herschel Telescope at La Palma, is now being brought into use, and the first results are encouraging. The optics are as good as any in the world; so is the site, and the WHT is surpassed in size only by the Russian reflector, which is unsatisfactory, and the Palomar 200-inch, which is now almost 40 years old. There is also progress on the Nordic telescope at La Palma — a 100-inch, jointly organized and funded by Norway, Sweden, Denmark and Finland.

THE SUPERNOVA

I make no apology for returning to the subject of the Supernova in the Large Clouds of Magellan, because it is of extreme importance — and is, after all, the first naked-eye supernova since Kepler's Star of 1604.

In May I made a rather brief trip to South Africa to observe it. Certainly it could not be mistaken. I made the magnitude 2.4 at the end of the month,

The Sky This Month

WITH the lengthening nights, the stars are becoming more obtrusive. Of the planets, Venus and Mars are on the far side of the Sun, and are out of view this month, and so too is Mercury, though if you happen to go to the southern hemisphere you may glimpse it as a morning object during the first week of August. This leaves us with the two giants, Jupiter and Saturn, both of which are reasonably well placed.

Jupiter, magnitude -2.6 (far brighter than any star) now rises well before midnight, and even though it is in the south of the sky it cannot be mistaken. The famous Red Spot has not been in evidence lately, but no doubt it will soon return; meanwhile, a small telescope will show its cloud belts as well as its four bright moons (Io, Europa, Ganymede and Callisto) which would be naked-eye objects if they were not so overpowered by the brilliance of Jupiter itself. They look like tiny disks, but, as we know, they have turned out to be remarkable bodies — Ganymede and Callisto cratered and icy, Europa icy and smooth, Io red and violently volcanic.

Saturn is also in the southern sky, but is easily observed in the evening — and with a telescope its ring system, now wide open as seen from Earth, is truly magnificent. Also easy to see with a small telescope is Titan, which

has a considerable atmosphere made up chiefly of nitrogen. What lies beneath Titan's orange clouds is still a matter for debate, and we must wait for the next rocket probe — probably the Cassini Mission, which, alas, has (like all other projects) been put back by the American problems, and is not now likely to reach the Saturnian system for over ten years.

The Moon is full on August 9, and new on the 24th. This means that moonlight will interfere badly with the early stages of the Perseid meteor shower, which is a pity. The Perseids make up much the most reliable shower of the year, and they never fail us; anyone who goes outdoors and stares up at a dark, clear sky for a few minutes between July 27 and about August 17 will be unlucky not to see several meteors. Yet even the most brilliant Perseid is likely to be much smaller than a pin's head. It seems strange now to reflect that even in the early 1950s, before the 1957 launch of Sputnik I, there were still many authorities who firmly believed that any craft venturing beyond the top of the screening atmosphere would be at once battered to pieces in a sort of cosmic hailstorm! This is one of many 'bogeys' which has turned out to be a false alarm.

which means that it was much the brightest object in that part of the sky; its colour was orange — it looked very like a star of type late K, but of course it is much more dramatic than any normal star. It completely outshone the Large Cloud itself, which is, remember, a very considerable star-system even though it is smaller than our own Galaxy.

The supernova is a strange object, and it is not conforming to any set pattern. Supernova are of two types. In Type I we have a binary system, and the outburst is due to the complete destruction of white dwarf component. With Type II we have a single, massive star which runs out of nuclear 'fuel' and implodes; the implosion is followed by a shock-wave which blows the main star to pieces, leaving a small, ultra-dense remnant made up of neutrons. SN1987A is certainly not a Type I, and is an unconventional Type II. It seems that the progeni-

tor star was a blue supergiant rather than a red star, as had been expected. It is underluminous by supernova standards, and instead of starting to fade after its outburst it has brightened slowly. We must be dealing either with a very exceptional object, or else with a new and previously unexpected class of supernova.

Quite apart from the behaviour of the star, we are learning much more about the effects of supernova upon interstellar material. As long ago as 1957 (the start of the Space Age!) Hoyle, Fowler and the Burbidges showed that supernova explosions could 'spray' heavy elements into space. And by good fortune, a Japanese satellite, just put into orbit, has been carrying X-ray equipment capable of detecting low concentrations of heavy elements. It now seems, from these results, that the area near the supernova contains a great deal

of iron — and this is exactly what would be expected on the basis of theory.

Obviously, the way in which heavy elements such as iron are created will tell us a great deal about the past history of the universe; it is thought that the fundamental particles were produced at the instant of the 'big bang', around 15,000 million years ago, but the more complex elements did not appear until later — and supernova play a vital role. So it is understandable that astronomers are doing all they can to extract every piece of information possible from SN1987A, which has been so conveniently provided by Nature. It may, after all, be many centuries before we have another chance. If you have the opportunity to 'go south' and see the supernova for yourself, I strongly recommend you to do so. I can assure you that it is worth seeing.

PI

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Wanted Sept 80 Practical Electronics metal detector and teletext articles will pay £1.50 and refund postage. Graham Curtis, 134 Bay View Road, Westward Ho, Devon, EX39 1BJ.

Scope Iwatsu SS5702 20MHz Dual Beam Oscilloscope excellent condition. Manual + probes £200 or exchange Cortex Comp. L. Millhouse, 7 Bentinck Street, Mansfield, Notts, NG18 2QQ.

Wanted. Remote control TX RX for SABA tele — Commander cost doesn't matter. Phone Huddersfield (0484) 663114 Gary Riley, 4 Kestrel Bank, Netherton, Huddersfield, West Yorkshire, HD4 7LD.

Epson P40 serial printer wanted good condition. Tel 0790 52506. P.C. Woodgate, Church Lane, Mavis Enderby, Spilsby, Lincs, PE23 4EE.

Tektronix 565 Oscilloscope Dual Beam with plug in modules £240 o.n.o. Chesterfield 78211 Evenings. D.J. Wortley, 3 Foljambe Avenue, Walton, Derbyshire, S40 3EW.

O.A.P. needs service sheet manual for Rediffusion (Shannon) B & WTV Type no MU24 30. Buy, loan 13A series? G. Martin, 39 Green Lane, Middleton, Lancs. M24 2NF 061 653 8275 (pm).

Wanted. Instruction book for T.M.K. 117 multitester, also sig gen 41 NOMBREX in good order. Phone: 0273 737838 M. Edwards, 22 Channings, Kingsway House, East Sussex, B43 4FT.

Softy 2 Eprom Programmer + manual, all leads, as new quick sale £150 ono. Stephen Carr, 88 Lytham Road, Fulwood, Preston, PR2 2EL. Tel: 732762.

Wanted. Technical manual for Enterprise computer, plus any other information. A Reekie Tel: 051-531 7140

Wanted. Practical Electronics 1980 — 1985 and ET1 1980 — 1985. Charles Abonyo, P O Box 1161, Nakuru, Kenya.

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REMEMBER SUBSCRIBING TO
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This speech synthesiser uses the SSI 263A speech chip with PET Basic, easily adaptable to the C64 and BBC. Part two concludes the project by describing the construction and practical usage.

PE MICRO-CHAT

PART TWO BY MALCOLM HARVEY

There's someone on the allophone

The primary power source required is a nine volt supply, from a PP9 battery for example, or from a battery eliminator (mains adaptor), via SK2. The overall current drawn rises to about 50mA with all LEDs glowing. The raw 9V supplies IC5 direct since this is flexible in its demands, with C4 offering smoothing.

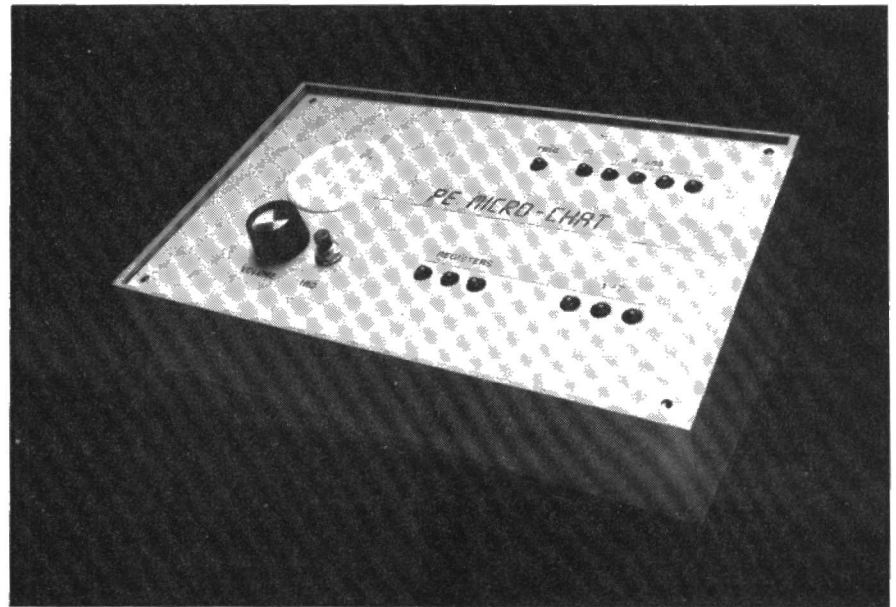
The remaining circuitry though needs a 5V supply. This is derived by biasing TR1 via R10 and the zener D1. The voltage seen at the emitter of TR1 will be approximately 0.6V below the nominal zener voltage at the base of TR1. Consequently, either a 5V6 or 5V1 zener will be satisfactory. Almost any NPN transistor can be used for TR1.

CONSTRUCTION

There should not be any problems here as long as you do your soldering satisfactorily. All the ICs should be used with DIL sockets, and you should discharge static electricity from yourself before inserting them. Observe their correct polarity, and that of D1, TR1, the electrolytics and the LEDs.

The link wires on the PCB can be made using resistor cut off leads. The speaker and VR1 should be mounted on the PCB, through holes drilled to size where marked. Use a cable tie or tough thread to hold the speaker at the rear.

Front panel drilling positions can be measured directly from the PCB. The switch is mounted direct on the panel, with its tags passing through a suitably sized hole in the PCB. Self adhesive PCB supports were used to secure the PCB to the rear of the panel. The only slightly tricky bit is ensuring that the LEDs pass



through the panel holes. These were drilled slightly larger than the LED diameter, and mounting grommets were not used. This helps alignment in case of slight maladjustment. The easiest way for mounting LEDs is probably to leave their legs long until finally correctly soldered. Insert them all into the PCB holes, but solder only lightly to one leg. Secure the PCB to the panel, carefully reposition the height and orientation of the LEDs until satisfied, then solder them properly.

COMPUTER PROGRAM

The program has been written in Pet Basic, but the differences between this and the Commodore C64 and the BBC are minimal in this particular

application. Guide line notes for converting it for the last two machines are given at the end of the listing.

Study of the program will show that a varied menu of main control options has been included, and that one of these is a Basic routine for checking the unit, main menu option 8. This routine should be run before using any of the other options once assembly has been completed. It simply sends out low speed data bits to the unit so that correct functioning can be observed by watching the LEDs. During this routine all control lines can also be observed on an ordinary voltmeter. It is also this routine that can be used as a guide line by owners of other computers, to assist in writing a program in their own machine's dialect.

Having proved the correct functioning, run main menu option 1. This sends the words entered into the Data statements about halfway through the listing, together with various register control codes, prefixed by an exclamation mark.

The message itself is simply a set of speech examples, and embodying a few register and phonetic alterations to give better understanding and tonal interest when listening to messages. In its written form it looks a bit like a foreign language, but even visually its meaning should be clear with a little examination. You can substitute your own corrections, and experiment with it.

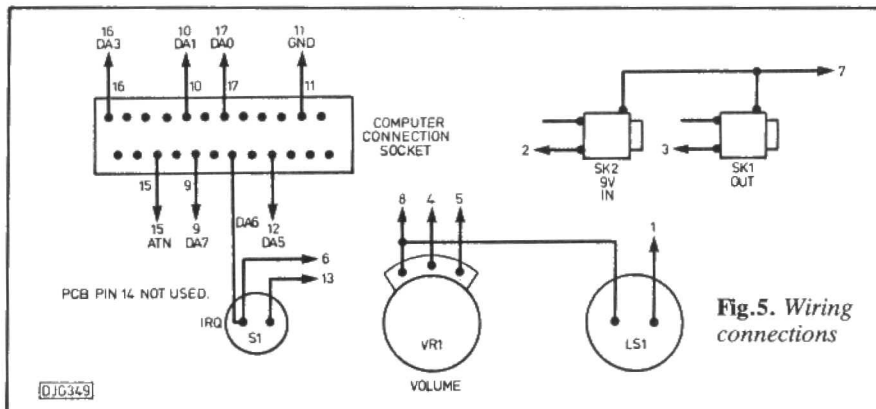


Fig.5. Wiring connections

TABLE 2: REGISTER INPUT FORMATS

Register Address				Register Name	Bus Input Bit Position							
RS2	RS1	RS0			D7	D6	D5	D4	D3	D2	D1	D0
A	LO	LO	LO	Duration/Phoneme (DR/P)	DR1	DR0	P5	P4	P3	P2	P1	P0
B	LO	LO	HI	Inflection (L)	L7	L6	L5	L4	L3	L2	L1	L0
C	LO	HI	LO	Rate/Inflection (R/N)	R3	R2	R1	R0	N3	N2	N1	N0
D	LO	HI	HI	Control/Articulation/Amplitude (C/T/A)	CTL	T2	T1	T0	A3	A2	A1	A0
E	HI	X	X	Filter Frequency (F)	F7	F6	F5	F4	F3	F2	F1	F0

CTL: Ignore. X: Don't Care

DEFINED REGISTERS

Table 2 shows the register input formats and functions. It is easier to use than it looks. Indeed, it is not actually necessary know how it operates unless you want very precisely to control and vary pitch, rate and other parameters actually during a message. As will be seen presently, all parameters can be menu set to preset factors and left at those settings throughout a message. However, a brief outline will allow you to experiment with greater sophistication.

Each pre-programmed register change must be preceded by an exclamation mark. This tells the computer that the next three letters are register control codes. The program takes care of sending the correct digits representing these letters.

The first letter selects the register block as shown in Table 3, in order of A to E (1 to 5). The next two letters define the data number to be sent. D7 to D4 are taken as a separate 4-bit binary block, ranging from decimal 0 to decimal 15. The required decimal number is translated into a true ASCII character, which in fact also corresponds to the same numbered letter in the alphabet, though zero is translated as the '@' symbol. Thus, setting each of D7 to D4 to logic 1, results in binary 1111, the decimal number of which is 15, therefore the associated letter is O. The third letter in the code represents D3 to D0, as a 4-bit code, and is arrived at similarly.

EXAMPLE

Taking the third line in the table as an example, the speech rate is set by bits R3 to R0, that is, bits D7 to D4. The inflection rate selected is determined by N3 to N0, i.e. bits D3 to D0. So, to set the speech rate at 7 and the inflection rate at 11, for example, the ASCII lettered equivalents are G and K respectively. The register line is three, thus letter C, and the control instruction is then entered as !CGK. Similarly, to set the frequency at 234 for example, the binary number is 11101010. Splitting this into two 4-bit blocks, we get 1110 which is decimal 14 or letter N, and 1010 which is decimal 10 or letter J. The

control code then becomes !ENJ. Any of the registers can have their settings changed at any time during speech synthesis. Control codes can even be inserted into a word to change its sound characteristics.

After each specific register change has been sent, the computer automatically defaults back to register line A, and so the unit processes incoming data as duration and phoneme instructions. Study of the program routines after the 'Change Parameters' option set into the listing will show in greater detail the calculations for register settings.

As a small note of caution, bit D7 in register line 4 is marked CTL. You should avoid setting this bit in register control instructions. Its function is complex, and if incorrectly set in conjunction with certain states of DR1 and DR0, loss of the return sync pulse from the chip could result. So ignore the existence of CTL; the program itself takes care of its required setting. Should you accidentally set it and lose program control, it may be necessary to switch off and reload the program.

FIXED PRESET REGISTERS

You only need to change register parameters in the above fashion if you are intent on extensive speech synthesis control. I feel sure that most people will find that they can simply use the automatic register setting routines, as

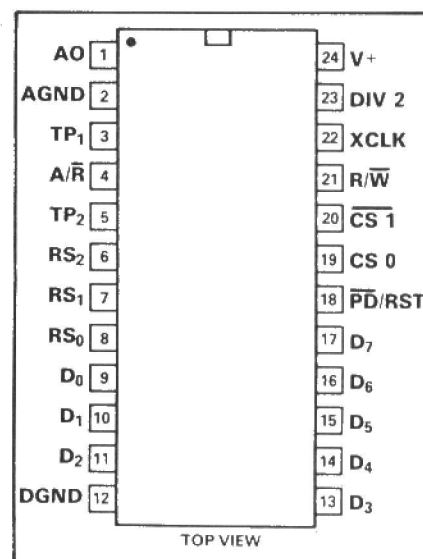
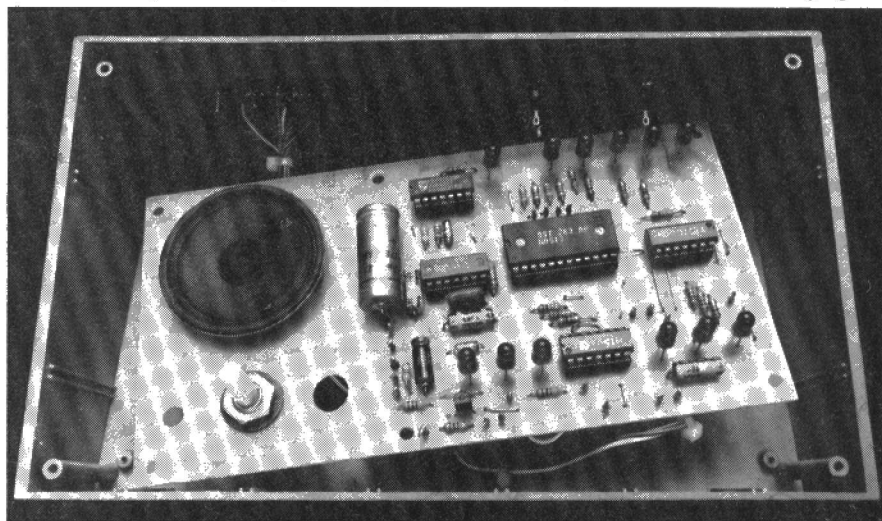


Fig.6. Pin connections of SSI 263A

available through main menu option 4. This displays the register functions on the screen, and the parameter ranges. It also displays a screen prompt asking what change you want to make. For example, if you want to change the pitch range (sub-menu number 4) to range 12, enter '412'. For range 5, enter it as '45'. To change the filter to range 213, enter the number as '7213', 7 being the sub-menu number for filter.

Once you have finished changing the



READERS' LETTERS

BIOFEEDBACK

Dear Mr Becker

May I please present a few comments on the article entitled "Biofeedback measurement circuits" in PE May 1987. To avoid lengthy script I would refer you for details to PE October 1983 and my article entitled "A Safe Relaxometer".

a). Any uninformed experimentation with the human body can be dangerous. There are in this country many people who have a slight malformation of the brain, of which they do not know: any periodic input to the senses in the frequency 15 to 20Hz precipitates an epileptic seizure. Examples are visual input from a stroboscopic Xenon tube, flickering sunlight when motoring down an avenue of tall trees, and auditory input from automobile body resonance at critical engine RPM. Relaxometers still on sale do this, and a warning is always wise.

b). With the exception of the 555 circuit, all circuits shown are more complex and expensive than the simple one which does the job adequately with one op amp chip, four transistors and a few diodes.

c). The protection of a sensitive meter from overload, and the expansion of central deflection may be simply obtained as shown in the earlier article.

d). Aluminium is an unsuitable electrode due to random pin-holes in the insulating alumina surface. The design of completely reliable and suitable electrodes constructed from materials obtainable in a haberdashery shop are shown in the early article.

e). Medical research has shown that the measurement must be made as a variation of less than a micro-amp, perspiration does not enter into the suitable range, and it is non-linear conduction, and not resistance which is a measure of relaxation to be monitored. The old lie-detector never did measure alpha rhythm, but only indicated a burst of fear.

R.T. Lovelock, C.Eng. F.I.E.E.

in my designs that could realistically be expected to give any problems.

(b) The purpose of 'Experimental Electronics' is to provide interesting circuits for the experimenter rather than to give a definitive design. The heartbeat monitors may be more complex than a skin resistance monitor—they might also be very much more interesting to experiment with. They might also give better results, and having tried numerous biofeedback circuits I have always found the heart-rate types to be the most effective. I realise that others may not find this to be so, and two alternative types of monitor were therefore included in the article.

(c) There is, of course, no difficulty in increasing the sensitivity of the temperature measuring circuit, but I am dubious about the value of vastly increasing the sensitivity. I think a more reliable means of sensing skin temperature would be needed before this would be worthwhile (i.e. one where ambient temperature would have less affect on readings).

(d) I tried a number of metals for the electrodes (aluminium, steel, brass, copper) and results seemed to be much the same in each case, although some may well be much better than others for long term use. Obviously anyone who has access to the October 1983 issue of PE would be well advised to try out Mr. Lovelock's tried and tested method. (*All copies of this issue have now been sold. ED.*)

(e) I am not sure if I fully understand the first point here, but the skin-resistance circuit does operate at a sensor current of around 1 microamp. I did point out in the article that the conductive jelly type electrodes are not suitable for this application, and I also pointed out the limitations of lie detector circuits.

ROBERT PENFOLD

BIKE SPOTTING

Dear Sir

I am involved in time keeping at motorcycle race meetings, but find that existing timing methods are unreliable for accurate tracking of individual lap and race times. Can anyone suggest

a reliable automatic piece of equipment or circuitry that can identify each bike and record its passing time? From this information a computer would be used to calculate the necessary results.

N.S. Hooper, 4 Westminster Court, 81 Albermarle Road, Beckenham, Kent, BR3 2HP.

TRACK RECORD

Dear Editor,

Regarding your 'How to use these Tracks' advice, WD40 is a cheaper and readily available alternative to ISO draft, and

additional advantage is that it is not fugitive so that a prepared mask may be used several months later. Imperfect photocopies may be repaired before spraying with a black water-soluble (washable) O.H.P. pen. After spraying with WD40 doubtful areas may be repaired by using technical drawing ink such as RS 548-883. Incidentally, a preliminary very light spray with PCB lacquer such as RS 554-989, followed immediately by WD40 causes a build up of material on the photocopy tracks, and appears to increase the opacity of the black areas.

J.T. Bodiam, C.Chem. Alton.
I would welcome further confirmation of these views. Ed.

BOOKMARK

The following books have recently been received:

How to Get Your Electronic Projects Working. R.A. Penfold. Babani BP110. £1.95. The aim of this book is to help the reader overcome the problems of circuits not working correctly when first switched on. It indicates how and where to start looking for many of the common faults that occur when building up projects.

Electronic Circuits for the Computer Control of Robots. R.A. Penfold. Babani BP179. £2.95. The main stumbling block for most would-be robot builders is the electronics to interface the computer to the motors, and the sensors which provide feedback from the robot to the computer. The purpose of this book is to explain and provide some relatively simple electronic circuits which bridge this gap.

Simple Applications of the Amstrad CPCs for Writers. W. Simister. Babani BP191. £2.95. Shows how an Amstrad CPC464, 664 or 6128 with disc drive and DMPI or DMP2000 printer can be turned into a simple but adequate word processor by using a Basic program of only 15 lines.

Modern Opto Device Projects. R.A. Penfold. Babani BP194. £2.95. Provides a number of practical designs which utilize a range of modern opto-electric devices, including such things as fibre optics, ultra bright LEDs and passive IR detectors etc.

Computer Projects for Railway Modellers. R. Amos and M. Cock. Patrick Stephens Ltd. £4.99. 96 pages of features, circuit diagrams and program listings for the Sinclair ZX Spectrum and BBC model B.

Microprocessor Engineering. B. Holdsworth. Butterworths. £15.95. Gives a clear and authoritative account of the hardware and software techniques employed in microcomputing systems. Concentrates on the Intel 8085A, with reference to other 8 bit microprocessors as necessary to give thorough instruction on the design and programming of systems using those processors as central elements.

Build a Better Music Synthesiser. T. Henry. Tab Books. £10.70. The book claims to provide start-to-finish details for building a complete studio-quality synthesiser that rivals any commercially-made unit.

Human Factors in Engineering and Design, 6th edition. M.S. Sanders and E.J. McCormick. McGraw-Hill. £33.95. In over 600 pages this book deals with the field of Human Factors, or Ergonomics as it is called, which in simple terms refers to the art and techniques of designing systems and equipment for human use. The previous five editions were important resources for human factors professionals. This sixth edition is additionally intended as a text book for use in upper-division and graduate-level human factors courses.

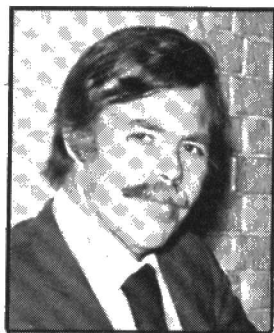
Wiring and Cable Designer's Handbook. B.S. Matisoff. Tab Books. £29.95. A state-of-the-art text book of design techniques and manufacturing methods needed to produce reliable cable and wiring assemblies suited to today's complex electronic environments.

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Dear John

Regarding the points raised by Mr. Lovelock:

(a) Mr. Lovelock is of course correct here, but there would seem to be no devices included



**REPORT BY
TOM IVALL**

INDUSTRY NOTEBOOK

ABSTRACTION AND ALIENATION AT WORK

More and more administration is being carried out by automated systems. Automated that/is, except for the hands "chained" to the keyboard.

LAST month I wrote about 'use value' and 'exchange value' and deplored the fact that the latter seems to be dominating the former, nowadays with the help of electronic systems. The general concept of value is a very mysterious one, eluding precise definition. What makes exchange value, in particular, so important and apparently so real is that it can be measured in units of money. The price of a particular hi-fi set is £399.99 — the precision is staggering! Such exact calculation, or so it appears, tends to blind us to the fact that, fundamentally exchange value is still arrived at by a very peculiar process. Somehow the seller and the buyer agree on an abstract quantity which usually dissatisfies them both. One of them feels that the price is too cheap and the other that it is too dear. Nevertheless, whenever a transaction is achieved they obviously have agreed on a figure, and so a kind of precision appears. Numbers are magicked out of thin air.

When money is represented by tangible objects like coins and banknotes, exchange value does seem to possess a certain solidity. But now we also have 'plastic money', in the form of credit cards and — just about to arrive — direct debit cards. Barclays Bank recently introduced its 'Connect' card system which electronically debits your bank account directly from the shop where you make a purchase. Credit and debit cards are tangible enough but they don't represent specific amounts of money. They simply act as keys for entering bank accounts.

Money held in banks and transferred between them has traditionally taken the form of marks made on paper. Cheques have been physically transported from place to place. Again the paper is tangible and the marks visible. But now the banks are beginning to use electronic funds transfer (EFT) more and more. And sooner or later shops will be installing EFTPOS, which is the same thing at the 'point of sale' (POS). Barclays' scheme is one step in this direction.

But, of course, money is only one of many things which are represented by symbols passing through electronic sys-

tems as digital data. Anything which can be measured, or described symbolically or graphically, is grist to the mill (a word, incidentally, which Babbage applied to the processor of his early mechanical computer). What I am really getting at, in our discussion on the interaction of electronics with society, is that we are beginning to experience a new form of alienation.

When the division of labour, technology, mass production and capitalism started to create the industrialised societies we have today, the late 19th-century sociologists used the term 'alienation' to describe the increasing separation of man from his work. The factory hand, unlike the self-employed craftsman, did not own the materials, tools or machines with which he worked. He had no control over the manufacturing processes, the timing and pace of his work, the integration of the materials or components into the final product, or the disposal of this product to customers. The effect of all this, the sociologists thought, was to depersonalise the human worker into a mere machine or thing. Psychologically, according to the theory, the worker experienced a sense of powerlessness and isolation.

I don't know whether this concept of alienation is valid. You would have to collect a lot of personal testimony from individuals to support it. But if it is indeed true, the present-day worker may well be experiencing a similar separation, not simply from tangible objects but from the information that represents these objects.

Electronic systems are such that they carry information so fast that it can't be grasped or seen like bits of paper in transit. The information is also inscrutable, because of its coded nature. It is encoded first into something like ASCII for data transmission purposes, and in certain cases such as money transfer it may be encrypted as well, to guard against interception and fraud. And the electronic symbols are largely inaccessible because they move through a network which only certain people have access to, with special equipment (e.g. computer terminals) in certain prescribed conditions. Furthermore, it is

predominantly the electronic system, not the human worker, which determines where and how the information shall be fed in and taken out.

Here we are concerned not so much with workers on the shop-floor but with administrators, accountants, middle managers, salespeople and a whole host of employees in the service industries who are dealing most of the time with information rather than tangible objects. In jobs of this kind, certainly, the workers have already become accustomed to the idea of symbols standing for real things or quantities in goods and services. But now, with the symbols being processed and transmitted electronically, these workers are separated not only from the primary goods and services on which their jobs depend but also from the representations of those realities.

Whether this is having a psychological effect on 'information workers' I don't really know. I suspect that it doesn't bother the more senior managerial people, because they are in a position of power to control the installation and use — even the design — of the electronic information systems. From their positions of authority they can have access to the information, through various peripherals, whenever they need it. But from speaking to workers, mainly women, who have the humdrum task of operating computer terminals and other peripherals, I get the firm impression that they do feel themselves alienated from the processes and functions they are performing. The old term 'factory fodder' has been replaced by the equally derogatory 'keyboard fodder'.

Fortunately, in manufacturing industry the alienation of shopfloor workers has been mitigated by automation — particularly since electronics has made automation so much more sophisticated. Clever robotic systems have taken over many of the dreary, repetitive tasks that made the earlier factory operatives feel like machines themselves. Let's hope that a corresponding development will help the increasing numbers of workers whose tasks are now defined by information processing systems.

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REMOTE JOYSTICK – infrared computer controller. Set of 2 PCBs.	124	£10.86
BABY ALARM – through-the-mains transceiver. Set of 2 PCBs.	125	£10.71
DEC 86		
VIDEO ENHANCER – manually adjustable video improvement.	126	£8.76
JAN 87		
VIDEO FADER – simple inexpensive video mixer	127	£4.50
VOICE SCRAMBLER – ideal for confidential transmission.	128	£8.06
JAN-FEB 87		
PROMENADER – 35 channel programmable light display controller:		
... Main Board	129	£30.68
... Power Supply	130	£9.53
... Playback Unit	133	£14.52
... Extension Prom	131	£9.05
FEB 87		
HISTAB – good variable workshop PSU	132	£8.79
MAR 87		
4 CHANNEL ENHANCER – adapts stereo to 4 channels	135	£4.60
LIGHT PEN – uses fibre optics for high accuracy	136	£4.10
TELEPHONE REPEATER – interface for phone bell extension.	137	£3.90
ULTRASONIC TAPE MEASURE – resolution to one centimetre	138	£9.50
APR 87		
VIGILANTE CAR ALARM – keeps cars alert to intruders	139	£5.90
SWITCH MODE PSU's – choice of three:		
... Stepper	140	£3.90
... Booster	141	£3.90
... Inverter	142	£3.90
INDUCTIVE LOOP TRANSCEIVER – remote control for models:		
... Transmitter	143	£3.90
... Receiver	144	£3.90
MAY 87		
BRIGHT FUZZ – Foot operated overdrive distortion	145	£3.90
JUN 87		
AUDIO SIGNAL GENERATOR – uses frequency synthesising techniques	146	£10.20
JUL 87		
WORD GENERATOR – produces binary words of up to 16 bits	147	£13.42
SCOPE STORE oscilloscope add-on data storage	148	£11.94
AUG 87		
PSEUDO STEREO – splits mono into simulated stereo	149	£7.37

THIS MONTH'S BOARDS

SEP 87		
SPEECH PROCESSOR – clarifies transmitted speech quality	150	£5.86
GCSE TIMER UNIT – versatile variable delay AWD and switching	151	£5.18
FUNGEN – triple waveform signal generator. Set of 2 PCB	152/153	£9.69
LIGHT CONTROLLER – economical delayed lamp switching	154	£4.64

APACHE



The Apache

A superb ready-built scale-model off-road racer complete with a 2-CHANNEL DIGITAL PROPORTIONAL RADIO CONTROL SYSTEM - for the price of the RC system alone!

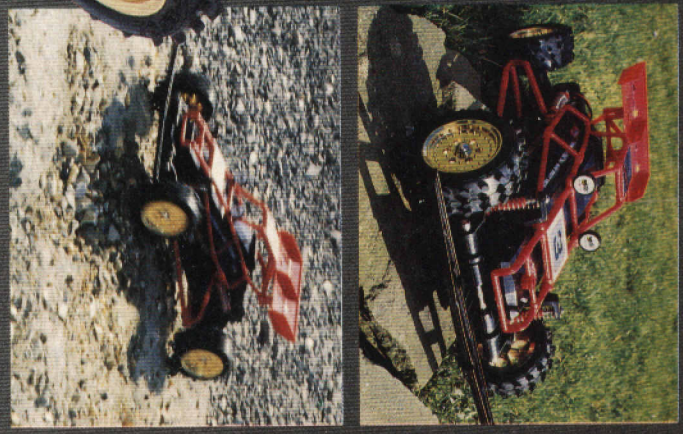
All this is included in the price:

- Ready-built 1/4 scale model car (overall size 325 x 186 x 130mm, 12.8 x 7.3 x 5.1in.).
- Front and rear low-profile semi-pneumatic rubber tyres.
- Front wheel independent suspension.
- High or low gear selection.
- Sealed box with differential gearing.
- Powerful motor gives scale speeds up to 140 mph.

**COMPLETE*
SYSTEM ONLY
£49.95!
(YP25C)**

Front and rear coil-spring shock absorbers.
2-channel digital proportional radio control transmitter (and receiver).
(Standard 27MHz AM - no licence required in UK).
Servo-controlled proportional steering.
Proportional motor speed control in forward and reverse.

*Batteries and in-lead charger not included. Car requires 8 AA cells (in-lead recommended YG00A £1.35 each). Transmitter requires 6 AA cells, (alkaline FK64U 55p each or in-lead as above). NB - and if you have a collision at 100mph or more, you'll be pleased to hear that spare parts are available.



Please rush me my Apache model racer, with 2 channel digital proportional radio control system, I wish to receive:

	Code	Qty	Price
Apache model racer	YP25C		
AA in-lead battery	YG00A		
AA alkaline battery	FK64U		
		Total	

All prices include VAT. Please add 5p towards postage. If order below £5.00, please add 50p handling. I enclose cheque postal order made payable to Maplin Electronic Supplies Ltd, or see credit card details. Here are my personal details:

Customer Number: _____

Name: _____

Address: _____

Post Code: _____

I authorise you to debit my Credit Card account for the cost of goods despatched.

Credit Card Number:

Access/American Express/MasterCard/Visa: _____

Delete as required

Note: Goods will be despatched only if the address given is the cardholder's address. If ordering by Credit Card please sign.

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